Bull Trout Distribution, Movements and Habitat Use in the Walla Walla River Basin

2005 Annual Progress Report

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Abstract

A better understanding of bull trout *Salvelinus confluentus* life history strategies is necessary to identify corrective actions that will make progress toward recovery in the Walla Walla Basin. This report describes studies conducted by the U.S. Fish and Wildlife Service (FWS) during 2005 on the mainstem Walla Walla River (WWR) with the goal of obtaining detailed information on bull trout life history to assist with development and evaluation of recovery actions. These studies were designed to describe seasonal distribution and movements, and to determine the physical conditions that comprise suitable habitat for bull trout.

We conducted snorkel surveys in the WWR from July through November 2005 to describe the spatial and temporal distribution of bull trout. The number of bull trout was compared among months and between stream segments with different streamflow, water temperature and physical habitat conditions to determine if abundance varied as a function of impacted and un-impacted conditions, or as a function of changing seasonal conditions within the study area. More bull trout were observed in the less impacted stream segment than the highly impacted stream segment downstream of the Little Walla Walla Irrigation Diversion, during all months except October. Also, bull trout were observed during all months in the less impacted stream segment and were only observed during October and November in the highly impacted segment, when flows had increased and temperatures decreased. Limited physical habitat as a result of low streamflows, high water temperatures, lack of continuous riparian cover, reduced groundwater inflow, and poor mesohabitat conditions all likely contributed to the reduced number of bull trout downstream from the diversion. In an effort to further understand why and to what extent bull trout use the Nursery Bridge Dam (NBD) pool, snorkel surveys were conducted at NBD from July through November 2005. Bull trout were observed at NBD throughout the sampling period and at times monthly average maximum temperatures exceeded 19 ºC. Our observations suggest that bull trout are currently using areas characterized by low streamflows and elevated water temperatures, and any improvements that can be made to improve physical conditions will help bull trout express the migratory life history that requires use of these areas.

To better understand seasonal movements of bull trout, we operated a screw trap and passive integrated transponder (PIT) detection arrays. The screw trap was operated during January through April and June. The screw trap was not operated during May due to high flows and personnel limitations. Results indicated that downstream movement occurred from January through April. The PIT tag detection arrays were operated in the South Fork Walla Walla River (SFWWR), the East and West bank ladders at NBD, Oasis Road Bridge (ORB) and Mill Creek Diversion Dam (MCD) to describe bull trout movement patterns. The SFWWR and upper Mill Creek are relatively pristine. The NBD and MCD arrays are located where habitat becomes highly degraded. The ORB array is located near the mouth of the WWR and was installed to detect movements between the WWR and Columbia River. Adult bull trout were detected moving upstream past NBD in the WWR during May and in the SFWWR during June and July, presumably to spawn. Adult bull trout were also detected moving downstream in the SFWWR and past NBD in October and November to overwintering areas. Similar patterns were observed in Mill Creek at MCD. Adult bull trout were observed moving upstream during April and May and downstream during October and November. Subadult bull trout dispersed downstream past

NBD during January, May, July and October through December 2005. Subadult bull trout were not observed dispersing downstream past NBD during August and September, when streamflows are generally low and temperatures relatively warm. Similarly in Mill Creek, subadult bull trout dispersed downstream during April through June, October and December. Subadult bull trout were not observed dispersing downstream during July through September, when streamflows are generally low and temperatures relatively warm. No bull trout were detected at ORB.

The 2005 redd surveys for the index reach of the SFWWR were conducted by FWS and the Oregon Department of Fish and Wildlife on 26 September and 17 October 2005. The cumulative number of bull trout redds enumerated over two surveys was 170. Microhabitat spawning suitability data were collected during 2004 and 2005. From those data, a multivariate logistic regression model was developed that could be used to predict the suitability of instream conditions for spawning bull trout. The combination of depth, substrate and mean column velocity resulted in the best fit model. Mesohabitat and microhabitat suitability data were collected for rearing bull trout at locations where fish were found during snorkel surveys from July through November but results were not reported. Efforts were focused on development of the spawning habitat suitability model.

A stream gage was successfully operated at Harris County Park to monitor flows while collecting data for the habitat suitability model and to determine the nature of instream working conditions for logistical planning during 2005. Water quality data that were collected from January to December of 2005 at the Harris Park gauge site complied with Oregon Department of Environmental Quality water quality standards for temperature, pH and dissolved oxygen standards.

Introduction

Bull trout *Salvelinus confluentus* were officially listed as a Threatened Species under the Endangered Species Act (ESA) in 1998. The U.S. Fish and Wildlife Service (FWS) subsequently issued a Draft Recovery Plan for the Umatilla-Walla Walla Recovery Unit (U.S. Fish and Wildlife Service 2002, Chapter 10). The goal of bull trout recovery planning in the Umatilla-Walla Walla Recovery Unit is to describe courses of action necessary for the ultimate delisting of this species, and to ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout distributed across the species' native range (U.S. Fish and Wildlife Service 2004, Chapter 10-revised). To meet this overall goal, the FWS has identified four recovery objectives which establish the basis for work conducted by the Columbia River Fisheries Program Office (CRFPO) in the Walla Walla Basin:

- Maintain current distribution of bull trout within the Core Areas and re-establish bull trout in previously occupied habitats,
- Maintain stable or increasing trends in abundance of bull trout,
- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and
- Conserve genetic diversity and provide the opportunity for genetic exchange.

Bull trout, which are native to the Walla Walla Basin, exhibit both migratory and resident life history strategies. Fluvial bull trout spawn in headwater streams and juveniles rear in these streams for one to four years before migrating downstream as subadults to larger mainstem areas, and possibly to the Columbia River where they grow and mature, returning to the tributary stream to spawn (Fraley and Shepard 1989). This same pattern can also be observed in the adfluvial life history strategy with the primary difference being subadult migration to a lake rather than larger mainstem river areas. Downstream migration of subadults generally occurs during the spring, although it can occur throughout the year (Hemmingsen et al. 2002). These migratory forms occur in areas where conditions allow for movement from upper watershed spawning streams to larger downstream waters that contain greater foraging opportunities (Dunham and Rieman 1999). Stream-resident bull trout also occur in the Walla Walla Basin, and they complete their entire life cycle in the tributary streams where they spawn and rear. Resident and migratory forms of bull trout may be found living together for portions of their life cycle, however it is unknown if they can give rise to one another (Rieman and McIntyre 1993). Bull trout size is variable depending on life history strategy. Resident adult bull trout tend to be smaller than fluvial adult bull trout (Goetz 1989). Under appropriate conditions, bull trout regularly live to 10 years, and under exceptional circumstances, reach ages in excess of 20 years. They normally reach sexual maturity in four to seven years (Fraley and Shepard 1989; McPhail and Baxter 1996).

When compared to other North American salmonids, bull trout have more specific habitat requirements. The habitat components that shape bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (U.S. Fish and Wildlife Service 1998). Throughout their lives, bull trout require complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Watson and Hillman 1997). Juveniles and adults frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). McPhail and Baxter (1996) reported that newly emerged fry are secretive and hide in gravel along stream edges and in side channels. They also reported that juveniles are found in pools, riffles, and runs where they maintain focal sites near the bottom, and that they are strongly associated with instream cover, particularly overhead cover. Bull trout have been observed over-wintering in deep beaver ponds or pools containing large woody debris (Jakober 1995). Habitat degradation and fragmentation (Fraley and Shepard 1989), barriers to migration (Rieman and McIntyre 1995), and reduced instream flows have all contributed to the decline in bull trout populations in the Columbia Basin.

In summary, bull trout need adequate streamflows and the corresponding habitat for each of the different life history functions at specific times of the year in order to persist in the Walla Walla Basin. Instream flows and the associated habitat must be adequate to provide spawning opportunities, rearing opportunities, cover, forage, seasonal movement, migration opportunities, and over-wintering refuges.

Background

The Walla Walla Basin in northeastern Oregon (OR) and southeastern Washington (WA) is a tributary of the Columbia River that drains an area of 4,553 km^2 (Northwest Power and Conservation Council 2004). The Walla Walla Basin is comprised of the Touchet River Subbasin, the Mill Creek Subbasin, and the Walla Walla River (WWR) Subbasin. The primary headwater tributaries originate in the Blue Mountains and include the North and South Forks of the Walla Walla River, upper Mill Creek, and the North Fork, South Fork, and Wolf Fork of the Touchet River (Figure 1). The Walla Walla Basin historically supported a number of anadromous and resident, native salmonid populations including: spring and fall Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), redband trout (*O. mykiss* subpopulation), bull trout (*S. confluentus*), mountain whitefish (*Prosopium williamsoni*), and summer steelhead (*O. mykiss*) (Northwest Power and Conservation Council 2004). Currently, steelhead are the only remaining native anadromous salmonid population in the Walla Walla Basin. A supplementation program for Chinook salmon was initiated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in 2000 in the South Fork Walla Walla River (SFWWR) using outplanted adults to initiate spawning. The current plan is to continue supplementation using spring releases of Chinook salmon hatchery smolts. Populations of native redband trout, bull trout, and mountain whitefish still persist in the Walla Walla Basin.

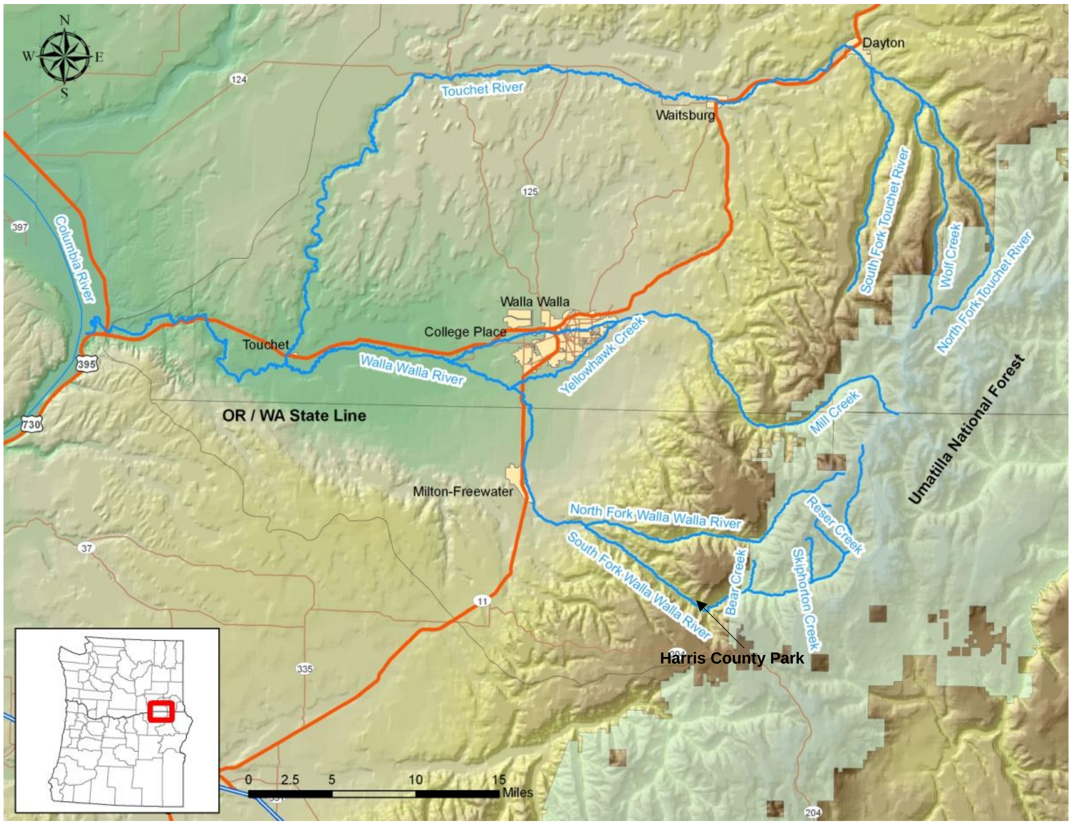

Figure 1. Map of the Walla Walla Basin showing the Touchet River, Mill Creek, and the Walla Walla River subbasins, and the Umatilla National Forest.

Most bull trout in the WWR Subbasin spawn in the SFWWR between Skiphorton Creek and Reser Creek (Figure 1) during September and October. Spawning occurs within the Umatilla National Forest where habitat conditions are relatively pristine and un-impacted by human disturbance. Spawning by both resident and fluvial bull trout has been previously documented in the SFWWR (Buchanan et al. 1997), and more recently documented during annual spawning ground surveys conducted by the Oregon Department of Fish and Wildlife (ODFW) and others.

ODFW collected data on bull trout movement and passage in the WWR while monitoring steelhead migrations through the West bank fish ladder at Nursery Bridge Dam (NBD) (river kilometer (rkm) 74.3) in Milton-Freewater, OR. The trap was typically operated from December through late May/early June from 1994 to 2001 (T. Bailey, ODFW, pers. comm. February 2004). Trap data from 1994 through 2001 (Figure 2) suggested that upstream adult bull trout migration typically began in March, peaked in May, and probably neared completion in June. Although observations of bull trout passing the fish ladder decreased in June, the trap was pulled during the last half of May in four of the eight years sampling was conducted, and it was pulled prior to mid-June during the remaining four years.

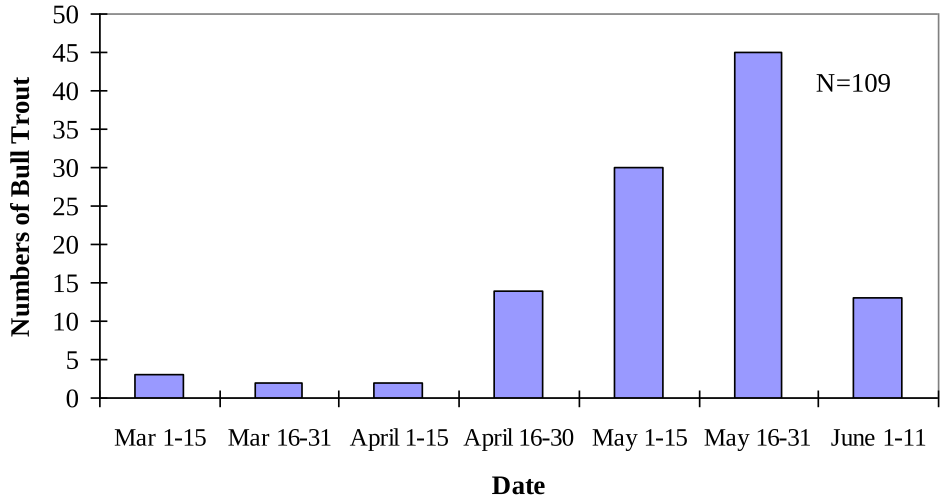

Figure 2. Total numbers of adult bull trout moving upstream in the WWR past NBD in Milton-Freewater, OR based on bi-weekly trap counts from 1994-2001 at the West bank fish ladder (T. Bailey, ODFW).

The CTUIR and ODFW conducted radio telemetry studies from 2001 through 2004 to monitor migration timing for adult fluvial bull trout moving between the SFWWR spawning area and mainstem wintering areas. They confirmed that some adult bull trout overwinter as far downstream as the OR/WA state line (Mahoney 2003).

The CTUIR also conducts video monitoring of fish passage at the East bank fish ladder at NBD. Observations are recorded by species and direction of travel, but fish size usually cannot be determined. Their observations included both large and small bull trout, likely representing both fluvial adults and subadults. During 2004 the FWS conducted video monitoring at the West bank fish ladder at NBD. During 2005 ODFW conducted video monitoring at the West bank fish ladder at NBD.

It is unclear if there is an active downstream migration of fluvial subadults from the SFWWR spawning grounds as has been observed in adfluvial systems (Fraley and Shepard 1989), or if fish simply disperse downstream. The U.S. Geological Survey, Utah Cooperative Fish and Wildlife Research Unit started a bull trout population assessment in the SFWWR in 2002 to estimate abundance, size structure, and other demographics (Budy et al. 2003, 2004). As part of a mark-recapture study to estimate abundance, they applied both passive integrated transponder (PIT) tags and Floy tags. They installed PIT tag detection systems or arrays in the upper SFWWR near Harris County Park and Bear Creek (Figure 1) to determine movement and survival. These arrays documented downstream movement of subadult bull trout during most months. These PIT-tagged bull trout subsequently moved downstream and were available for additional observations and/or detections. The total number of fish, or proportion of the population that disperses or migrates downstream from the SFWWR spawning area to impacted mainstem habitats, and their fate as water temperatures increase during the summer irrigation months is unknown. The ODFW have been capturing and PIT tagging bull trout in upper Mill Creek near rkm 42 since 2000 to investigate life history strategies, primarily focused on spawning migrations. In 2005 they initiated a study to investigate the seasonal movements of subadult fluvial bull trout in Mill Creek (Moore et al. 2005). They continued PIT tagging bull trout in upper Mill Creek and installed a PIT tag detection array at Kiwanis Camp Bridge (rkm 34.7) Although the work was focused in upper Mill Creek, PIT tagged individuals that survived and moved downstream into our study area were available for additional detections.

Physical habitat generally becomes increasingly degraded downstream from the Umatilla National Forest Boundary on the SFWWR and mainstem WWR. Factors that have degraded physical habitat as well as stream channel morphology include historical in-channel gravel mining and the construction of flood control structures. Flood control measures required straightening of the channel, construction of levees to contain flood waters, and construction of grade control structures to dissipate energy from high water events. In addition, a section of the mainstem from Milton-Freewater, OR north to the WA state line was seasonally dry from the late 1800's through 2000. A major irrigation diversion in Milton-Freewater at Cemetery Bridge removed most or all of the streamflow during parts of the irrigation season (April-October). Natural seepage of the surface water through the streambed alluvium into the shallow subsurface aquifer together with the diversions resulted in a dry streambed. This dewatering of the river often left large numbers of fish stranded in isolated pools (U.S. Fish and Wildlife Service 2004). Fishery biologists from ODFW and the CTUIR conducted salvage operations to move the stranded fish to watered areas upstream or downstream from the dewatered portion of the river. The traditional diversion of most of the surface water from the mainstem WWR and the subsequent dewatering of the channel and stranding of bull trout, steelhead, and other species, became both a political and legal issue following the listing of bull trout and steelhead as threatened under the ESA in 1998 and 1999, respectively. During the winter of 1999-2000, negotiations between local irrigators, the FWS, and environmental groups led to an out-of-court settlement to restore streamflows to the WWR. During 2002, 25 cubic feet per second (cfs) was bypassed at the Little Walla Walla River diversion near Cemetery Bridge in Milton-Freewater, OR, and since 2003, 27 cfs has been bypassed in June followed by 25 cfs for the rest of the summer to allow fish movement through the formerly dewatered area.

Quantitative habitat assessments may need to be conducted in the portions of the WWR where streamflow diversions and other impacts to stream channel integrity have reduced the amount of physical habitat that is available. Habitat suitability criteria will be required to conduct these assessments. However, few studies have been completed to determine habitat suitability criteria for bull trout (Baxter and McPhail 1997; Muhlfeld 2002). One study carried out by Fernet and Bjornson (1997) used a Delphi analysis to establish bull trout habitat preferences. Subsequently, they conducted an empirical study and found that preferences predicted from their analysis were suitable predictors of bull trout habitat use. Banish (2003) completed a habitat use study on bull trout in the eastern Cascades that found bull trout distributions to be influenced by microhabitat, mesohabitat, and stream-level variables using a logistic regression model. Budy et al. (2004) began data collection in 2003 to develop habitat preference curves and a logistic regression model to relate physical variables to bull trout occurrence. This work was conducted partly in the SFWWR, and transferability evaluations were conducted using the North Fork Umatilla and South Fork Wenaha rivers.

CRFPO bull trout studies were focused on the Walla Walla River Subbasin in 2005 with the goal of collecting and analyzing life history data to assist in assessing the relative merit of potential action strategies in making progress towards meeting the recovery goal outlined in Chapter 10, Umatilla-Walla Walla Recovery Unit of the Draft Recovery Plan (U.S. Fish and Wildlife Service 2004) for the recovery and delisting of bull trout. Specifically CRFPO studies were designed to address the following Recovery Plan Objectives:

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and

- Conserve genetic diversity and provide opportunity for genetic exchange.

To make progress on the habitat objective, a number of steps may be required. A fundamental step should be to determine the physical conditions that comprise suitable bull trout habitat. A subsequent step should be application of these habitat "criteria" to current conditions in the Walla Walla Basin to determine whether suitable habitat conditions are present. Following this evaluation, potential changes in current conditions, or actions to improve bull trout habitat in the Basin should be identified. And finally, implementation of those changes and/or actions should be pursued on a prioritized basis.

The recovery objective that describes genetic diversity could be accomplished by maintaining physical connectivity among local populations of bull trout to facilitate gene flow and genetic exchange. As the Recovery Plan discusses, connectivity consists of maintaining the fluvial component of each local population which includes providing conditions that allow fluvial adults to effectively move between spawning and wintering areas, and ensuring that movement of both fluvial adult and subadult bull trout can occur, at least seasonally, between local populations within each Core Area in the Recovery Unit. This includes establishing the physical conditions necessary for up- and downstream fish passage, and providing a continuum of suitable physical habitat to ensure the persistence of fluvial lifestages and to provide the opportunity for genetic exchange.

The general approach CRFPO used to plan studies in the Walla Walla Basin consisted of the following three steps:

- Identify data needed to assess if criteria for recovery objectives are being achieved;

- To that end, design and implement studies to describe bull trout distribution, movement, and seasonal habitat use patterns;

- Use the data and analyses from these studies to assist in guiding actions that will make progress towards bull trout recovery.

Study Area

Our study area in 2005 included the mainstem WWR from the forks to the OR/WA state line, a distance of approximately 17 river kilometers (Figure 3).

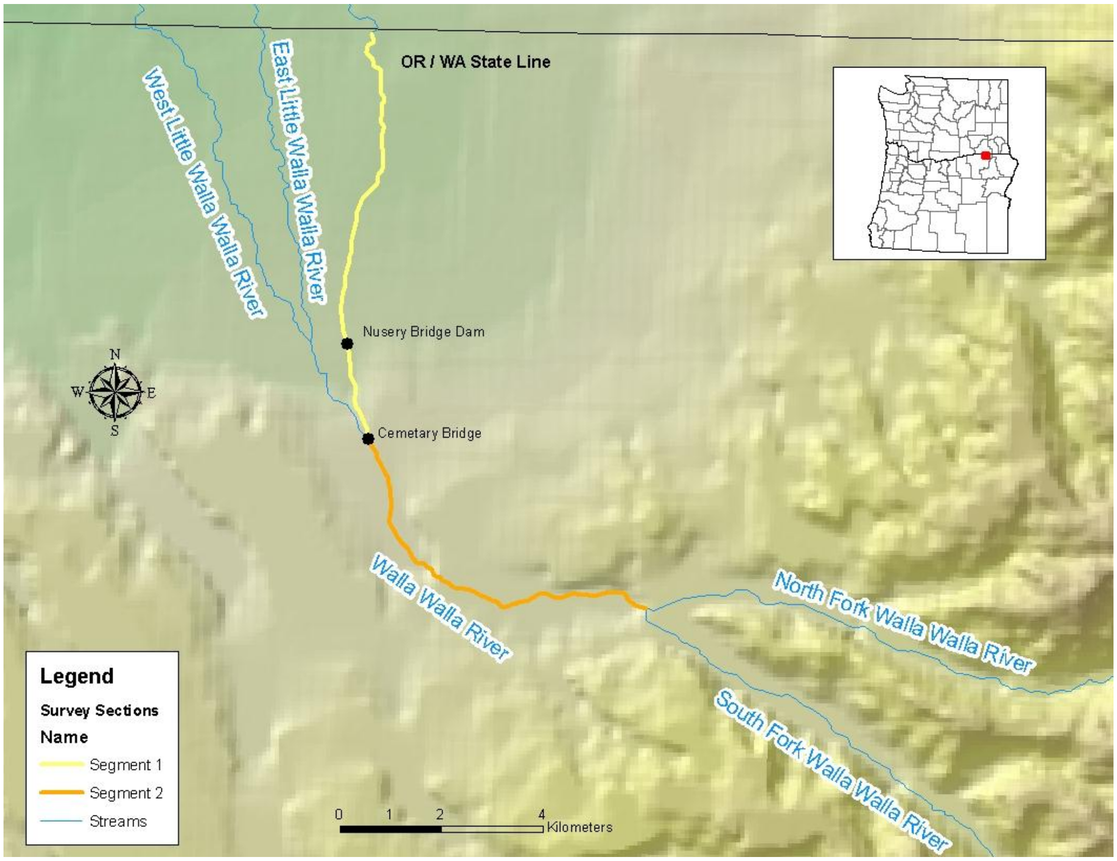

Figure 3. Map of the 2005 study area depicting 17 kilometers of the mainstem WWR divided into two segments. Stream segments that were sampled to determine bull trout distribution during 2005 are identified.

Study Objectives

Recovery objectives and criteria from Chapter 10 of the Draft Recovery Plan (U.S. Fish and Wildlife Service 2004) were the basis for our specific study objectives in 2005. Bull trout populations in the Walla Walla Basin consist of both resident and fluvial, or migratory life history strategies. Resident bull trout in the upper WWR local population are primarily located in the SFWWR upstream from Harris County Park where impacts are minimal. Thus, our study objectives were designed to address the fluvial portion of this population. In addition, it is the fluvial portion of the population that enables interaction between local populations to provide the opportunity for genetic exchange. This has been referred to as connectivity, or “connecting” local populations of bull trout within a Core Area, as well as metapopulations of bull trout among Core Areas. In order to make progress towards these recovery objectives, the temporal and spatial distribution of the two relevant life history stages for fluvial bull trout were required.

Temporal and spatial distribution data were required for bull trout to determine habitat use, migration patterns, and movement needs. In addition, identification of areas that limit fish passage were needed for determination of passage flows. The following specific study objectives were designed to obtain these data during 2005:

1) Distribution –Determine A) the monthly spatial distribution of adult and subadult bull trout in two stream segments considering the different physical conditions among the segments and B) the monthly number of bull trout within segments as physical conditions change.

2) Movements – Describe bull trout movement patterns for adults between spawning and overwintering areas, and movement patterns for rearing subadults in the SFWWR and WWR.

3) Habitat suitability – Develop and validate habitat suitability models for spawning and rearing bull trout that can be used in the Walla Walla Basin and tested in other basins.

Methods

Distribution

Snorkel Surveys

Snorkeling has been used to detect presence, measure abundance, determine habitat preferences, and observe behavior of many fish species (Helfman 1983). More specifically, snorkeling has been used to monitor and evaluate salmonid species throughout the northwestern United States (Schill and Griffith 1984; Thurow 1994; Bonneau et al.1995). Snorkeling was employed in this study to determine spatial and temporal distribution of bull trout in the study area and to make comparisons of abundance between sections of the study area.

To make comparisons of abundance, we divided the study area into two segments. The lower segment (1) stretched from the OR/WA state line (rkm 67.1) to Cemetery Bridge (rkm 76.3) in Milton-Freewater, OR. The upper segment (2) began at Cemetery Bridge and continued upstream to the confluence of the South Fork and North Fork Walla Walla Rivers (rkm 84.2). The study area segments were delineated based on flow regime and habitat structure which resulted in part from human impacts such as diversions and dikes. In general, the riparian and stream habitat conditions are relatively pristine at the forks and become increasingly degraded downstream to the OR/WA state line (rkm 67.1).

The study area was further delineated based on mesohabitat type (i.e. riffle, race and pool) during habitat mapping exercises, which took place at base flows during 2003 (Gallion et al. 2010). Riffles were either too shallow or the water velocity was too swift to effectively sample and were not included in our sampling design. As a result, only races and pools were randomly sampled. We believe sampling races and pools was sufficient to describe distribution within the study area and to make comparisons of abundance between segments. Earle and

McKenzie (2001) suggest bull trout prefer pool habitat. Snorkel surveys conducted in 2003 determined that although bull trout were present in all habitat types, they preferred pool habitats (Gallion et al. 2010). In addition, pool habitat was more conducive to successful snorkel sampling on a monthly basis during varying seasonal flow conditions in the study area. Most of the land encompassing the habitat units in our study area is privately owned. Landowners were identified using Umatilla County assessment maps and then contacted in person to gain river access.

During 2005, we concentrated our efforts on the mainstem WWR from the forks to the OR/WA state line. Because we were sampling a smaller area than was sampled in 2004, we were able to increase the number of samples within each segment. We hoped that more samples in each segment would lead to a better understanding of the seasonal lower extent of bull trout distribution within the study area and increase our ability to detect differences in the number of bull trout between segments. On average, each month we sampled approximately 900 meters of the 17,100 meter long study area or about 5% of the overall habitat. Sampling was limited to pools and races and by landowner access. Sixteen habitat units were randomly chosen each month from each of the two segments sampled during July through November. Eight pools and eight races were sampled monthly in segment 2; however, only pool habitat was sampled monthly in segment 1 because of low flows resulting in an insufficient number of race habitats available. Low summer flows in addition to water withdrawal resulted in most habitat in segment 1 being classified as either pools or riffles. At the beginning of each survey, stream temperature was recorded at each unit. Two snorkelers and one recorder were required to survey each unit. Snorkelers began surveying at the downstream end of the unit and moved upstream reporting fish species and the number observed to the recorder. Estimated total lengths were recorded in 50 mm size classes starting with 25 mm. Chinook salmon (*O. tshawytscha*) and *O. mykiss* greater than 325 mm were lumped into one category by species. Specific locations of bull trout and mountain whitefish were marked with flagged washers for microhabitat measurements. A Global Positioning System (GPS) point was collected at bull trout and mountain whitefish locations using a Trimble GeoXT GPS unit. We used the number of bull trout observed to make comparisons between segments, and we summarized the size distribution of the sample. We also summarized the monthly densities and size distributions for Chinook and *O.mykiss* by segment.

Snorkel surveys in 2004 revealed that bull trout remain in the NBD pool (rkm 74.3) from June through November. In an effort to further understand why and to what extent bull trout use the NBD pool, snorkel surveys were conducted from July to November in 2005. This monitoring site was snorkeled monthly in addition to the sites chosen randomly. The NBD pool was deemed an anomaly and was not included in the study-wide distribution group, so it was not possible for it to be chosen at random each month. The same snorkel protocol used during our distribution snorkel surveys was followed but no habitat or microhabitat measurements were collected. Water temperature and the number of subadult and adult bull trout observed along with average monthly temperatures for NBD are reported.

Water Temperature

Water temperature monitoring was continued during 2005. Sixteen thermographs (Onset Computer, StowAway Tidbits) were deployed in the Walla Walla Basin (Figure 4) (Appendix A). Eleven thermographs were deployed in the WWR to collect data corresponding with snorkel surveys and screw trap operation. Four thermographs were deployed in the SFWWR to continue collecting stream temperature data that began in 2004. One thermograph was deployed at the Oasis Road Bridge PIT tag detection array (rkm 10.1) to monitor temperatures associated with detections of PIT tagged bull trout. Prior to deployment, data loggers were checked for accuracy using Oregon Watershed Enhancement Board (OWEB) water quality monitoring guidebook specifications and sampling frequency was set to 30-min intervals (OWEB 1999). Manufacturer specifications report an accuracy of +/- 0.2 ºC for the Onset StowAway Tidbit (-5 ºC to + 37 ºC). Each thermograph was placed in 1 ½-in (3.81-cm) diameter metal pipe housing, 4-in (10.16-cm) in length. The metal pipe housing was secured to the bank using ¼-in (0.635-cm) stainless steel cable. Every three months, temperature data were downloaded in the field with an Onset Optic shuttle and then transferred to a personal computer. Data were summarized using BoxCar Pro software version 4.3 (Onset Computer). Temperature data was verified using quality control measures as outlined in the OWEB protocol. If the difference between the data and the reference thermometer were outside the standard range of accuracy (i.e. > 0.4 °C difference) then it was noted (OWEB 1999). Thermograph placement was based on Thermal Infrared Radiometry (TIR) data collected in August 2003 which suggested that water temperatures increase ~ 0.5 ºC every 1.6 km between rkm 67.5 and rkm 96.2 (Faux 2003).

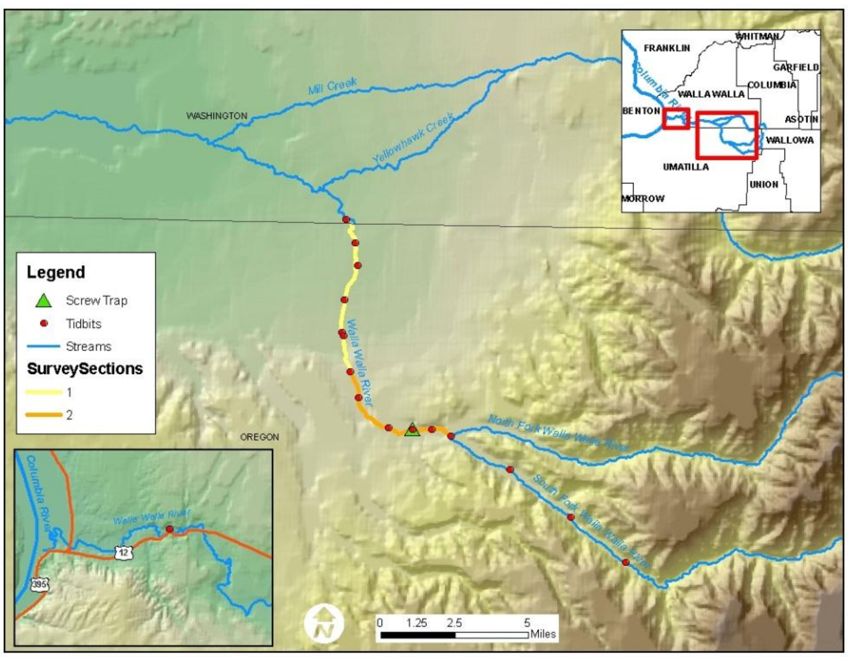

Figure 4. Distribution of thermographs throughout the SFWWR and mainstem WWR, segments of stream snorkeled and the location of the screw trap site used during 2005.

Movements

Rotary Screw Trap

A five-foot (1.52 m) diameter rotary screw trap (E. G. Solutions Inc. Corvallis, OR) was deployed in January through April and June during 2005 to characterize the magnitude and timing of bull trout dispersal or downstream migration from the SFWWR spawning area. The screw trap was not operated during May 2005 due to high flows and personnel limitations. The screw trap was operated at the Joe West Bridge site (rkm 82.0) in coordination with the CTUIR from 16 January 2005 to 24 June 2005, when operation was interrupted due to the increased potential for vandalism and the need for personnel to begin conducting snorkel surveys. In general, the trap sampled continuously with periods of inoperation due to severe river flow conditions and personnel limitations. While fishing, the trap was checked daily to ensure safe and efficient operation. During high flows, it was pulled and secured to the bank to avoid potential damage to the equipment. Captured fish were removed from the trap live box with a dipnet. Bull trout, Chinook salmon, and *O. mykiss* captured were anesthetized with MS-222 (tricaine methanesulfonate), scanned for PIT tags and measured for weight and length. Chinook salmon and *O. mykiss* were tagged by CTUIR with 12-mm PIT tags when possible. Un-tagged bull trout >120 mm were tagged with 23 mm PIT tags when trained personnel were present. All fish were released at a designated site downstream of the trap. Weekly trap efficiencies for bull trout, *O. mykiss*, and Chinook salmon were not calculated due to the intermittent nature of the trapping schedule and low bull trout captures.

PIT Tag Detection Arrays

Bull trout movements and distribution were also monitored using PIT tag arrays (Zydlewski et al. 2002). The relatively efficient passive monitoring using PIT tag detection arrays together with the ongoing tagging effort mentioned previously in the Background section of this report is part of our goal to better understand migratory bull trout life history, and the temporal and spatial aspects of their distribution and movements. The PIT tag arrays were installed previously at two locations in the SFWWR (Budy et al. 2003), and in the East and West bank fish ladders at NBD (Anglin et al. 2008) in the mainstem WWR (Figure 5). In general, these sites operated throughout 2005, except the West bank fish ladder at NBD (Figure 6) operated from 1 January through 13 June 2005, when the ladder was closed for passage. Additional arrays were installed at two new locations in the Walla Walla Basin during 2005. The new PIT tag sites were located at Mill Creek Dam (MCD), a water diversion dam managed by the Army Corp of Engineers, and Oasis Road Bridge (ORB). PIT tag detection arrays consisted of full duplex interrogation systems (Destron Fearing FS1001A), antenna arrays custom built for each application, and a laptop computer equipped with Minimon software (Pacific States Marine Fisheries Commission). Two antennas were installed in the fish ladder at the MCD site (Figure 7) near the upstream and downstream ends of the ladder on 25 February 2005. The antenna at the upstream end of the ladder remained functional throughout the year. The antenna at the downstream end of the ladder failed soon after installation and was replaced on 16 June 2005. In addition to the ladder antennas, one antenna was installed at the upstream end of the low flow outlet and operated from 17 March through 23 June 2005, when it failed. The antenna was not replaced due to poor performance related to its large size (~3 m^2) and loading of the electromagnetic field on steel components in close proximity to the antenna. A laptop computer was installed at the site on 7 April 2005. The array was linked by phone to the internet, permitting data to be automatically uploaded to the PIT tag Information System (PTAGIS) website every 6 hours.

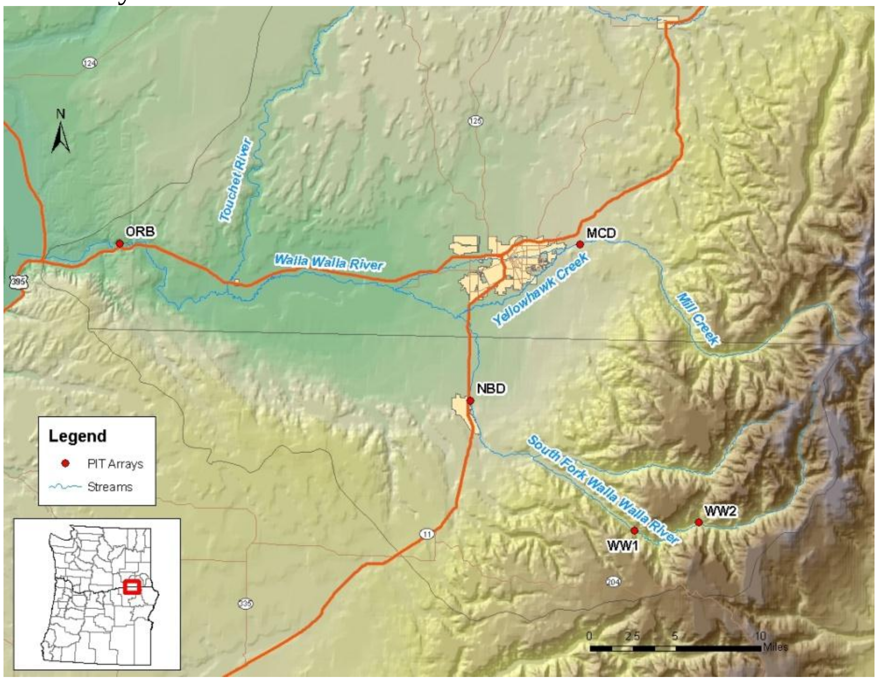

Figure 5. Locations of PIT tag detection arrays operated during 2005.

Figure 6. PIT tag detection arrays at the West (foreground) and East (background) Bank Nursery Bridge Dam Fish Ladders. Arrows indicate PIT array antenna locations. The East Bank antenna is on the interior of the fish ladder and is not visible.

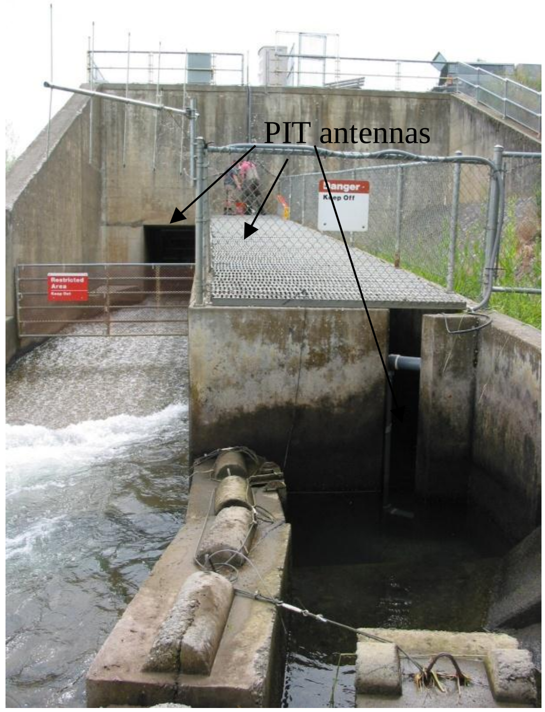

Figure 7. PIT tag detection array at MCD. Arrows indicate PIT array antenna locations in the low flow outlet (left) and in the fish ladder (right). The upstream ladder and the low flow outlet antennas are not visible.

In addition to arrays installed in the middle of the Walla Walla Basin at MCD and NBD to investigate movements into degraded habitats, we installed an array at ORB to investigate use of the Columbia River by Walla Walla Basin bull trout. Even though the site was upstream from McNary Pool backwater effects, a new antenna design (dual loop) was developed because water levels during winter and spring were too high to efficiently operate an array of standard antennas. The dual loop pass through design divided the antenna into two smaller electromagnetic fields, essentially allowing us to monitor twice the area of a standard antenna while maintaining similar detection efficiency. A single 1.8 x 3.3 m dual loop pass through antenna was installed in the thalweg at ORB to test the new design under spring flow conditions. Aluminum angle brackets were bolted to the basalt substrate, and the bottom of the antenna was secured to the brackets using nylon webbing. The top of the antenna was attached to the bridge with rope. Data collection began on April 15, 2005. The antenna remained intact and as spring flows subsided, three more 1.8 x 3.3 m dual loop pass through antennas were added to the site on June 17, 2005 using similar installation methods. Lastly, two 0.9 x 2.1 m pass through bank antennas were installed on December 6, 2005 to complete the array (Figure 8). A laptop computer equipped with Minimon software (Pacific States Marine Fisheries Commission) was installed at the site on September 12, 2005. Data were typically uploaded monthly to the PTAGIS website by FWS biologists. In addition to being detected at the ORB PIT array, PIT tagged bull trout have the potential to be detected at mainstem Columbia or Snake River dams. The PTAGIS database was queried for detections of Walla Walla Basin bull trout in the fish ladders and juvenile bypass systems at Priest Rapids and McNary dams on the Columbia River, and Ice Harbor Dam on the Snake River.

Figure 8. Oasis Road Bridge dual loop pass through PIT detection array.

The total numbers of detections, not including orphan tags (tags that have been detected but are not yet associated with a particular release), are summarized by species for the PIT detection arrays in the Walla Walla Basin. Movement data at Bear Creek detection array (WW2) contains detections of both resident and fluvial bull trout. Our focus is on the fluvial bull trout and results for WW2 are not reported. Movement data at the Harris Park Bridge detection array (WW1) were summarized by Budy et al. (2006). They inferred movement based on detections at the WW1 and WW2 arrays and annual active recaptures of fish. Detections at the NBD and MCD PIT arrays were separated into adult and subadult by examining size at tagging, length of time between tagging and first detection, and detection history. All bull trout >300 mm at the time they were PIT tagged were considered adults. Bull trout < 300mm were considered subadults unless there was a long time (~ 1 year) between tagging and first detection or if the detection history indicated a spawning migration. No bull trout were detected at the ORB array.

Routine inspection and maintenance of all interrogation systems were performed to ensure reliable data collection and system operation. PIT tag detection array operation and performance can affect the number of detections and should be considered when interpreting movement patterns observed in detection data. Two factors determine the efficiency of the PIT arrays to detect PIT-tagged bull trout within the passage routes monitored; site functionality and detection probability. Site functionality was summarized by the number of days one or more antennas were operational at each PIT detection array. Detection probability was determined by conducting antenna detection efficiency tests. In January, February, March and June 2005 at NBD, these tests consisted of passing a float with an attached PIT tag through the center of the antenna field 10 times per trial. Downstream and upstream detections were recorded and efficiency was calculated by dividing the total number of detections by the total number of trials (# detections/ # trials) and reported as a percent (Zydlewski et al. 2002). Separate trials were conducted for 12 and 23 mm PIT tags. Efficiency tests were discontinued at the West bank ladder in July 2005, based on prior tests which suggested efficiency was consistently near 100%. At the NBD East bank antenna, we measured the coverage of the electromagnetic field within and/or around the antenna from July through December 2005. Efficiency was calculated by dividing the area monitored by the electromagnetic field by the area where fish could pass (i.e. the size of the antenna). Similar tests were conducted at MCD from July through December 2005. The Efficiency of the ORB array, which spanned the entire width of the WWR, was determined by calculating the monthly proportion of water column monitored. Methods for estimating efficiency at the ORB array are further described in Gallion and Anglin (2009).

Habitat Suitability

Determination of the physical habitat preferences of bull trout is an important step in the process of evaluating existing conditions and developing actions to improve the habitat. Bull trout preference for specific ranges of microhabitat and mesohabitat variables must be quantified before an assessment of current conditions can be conducted, and before changes can be recommended to improve current conditions. Microhabitat variables are those that occur at point locations and they include water depth, water column velocity, river bottom materials or substrate, and cover. Mesohabitat variables that affect physical habitat on a larger scale include water temperature, canopy cover (riparian habitat), and channel structural components such as undercut banks, large woody debris piles, or boulder fields. We defined mesohabitat units as pools, riffles, and races. Mesohabitat variables affect habitat conditions over a relatively larger area rather than at a point location. Our goal is to create and validate habitat suitability models for spawning adult and rearing subadult and adult bull trout in the WWR and SFWWR. We began to develop the models by collecting spawning habitat data at redd locations and non-use locations in the SFWWR during 2004 (Anglin et al. 2008) and continued this effort in 2005. This data collection effort was preceded by bull trout redd surveys in the SFWWR including Reser and Skiphorton creeks. We also collected subadult and adult bull trout habitat data at locations where rearing fish were encountered during snorkel surveys and at non-use locations.

<u>Redd Surveys</u>

Multiple-pass spawning ground surveys were conducted by FWS and ODFW personnel every three weeks on the SFWWR from September through October 2005 to obtain an annual index of abundance. Surveys were planned to begin on 6 September but were postponed until the week of 26 September due to a forest fire in the drainage. An additional survey was conducted the week of 17 October. FWS biologists surveyed reaches 5 through 7 of the SFWWR between the Skiphorton Creek confluence and Section 20 Tributary (Figure 9). Surveyors began at the upstream end of each reach and walked/waded downstream enumerating redds, recording redd size, and recording estimated lengths of adults seen within the reach. Bull trout redds were categorized into small (<0.5 m), medium-small (0.5 m – 1.0 m), medium-large (>1.0 m – 1.5 m), or large (>1.5 m) size classes in an attempt to distinguish resident and migratory redds. Bull trout redds were assigned a unique number and marked with flagging to avoid counting redds multiple times and to identify individual redd locations. These marked locations provided the opportunity to return later to measure habitat variables used by spawning bull trout.

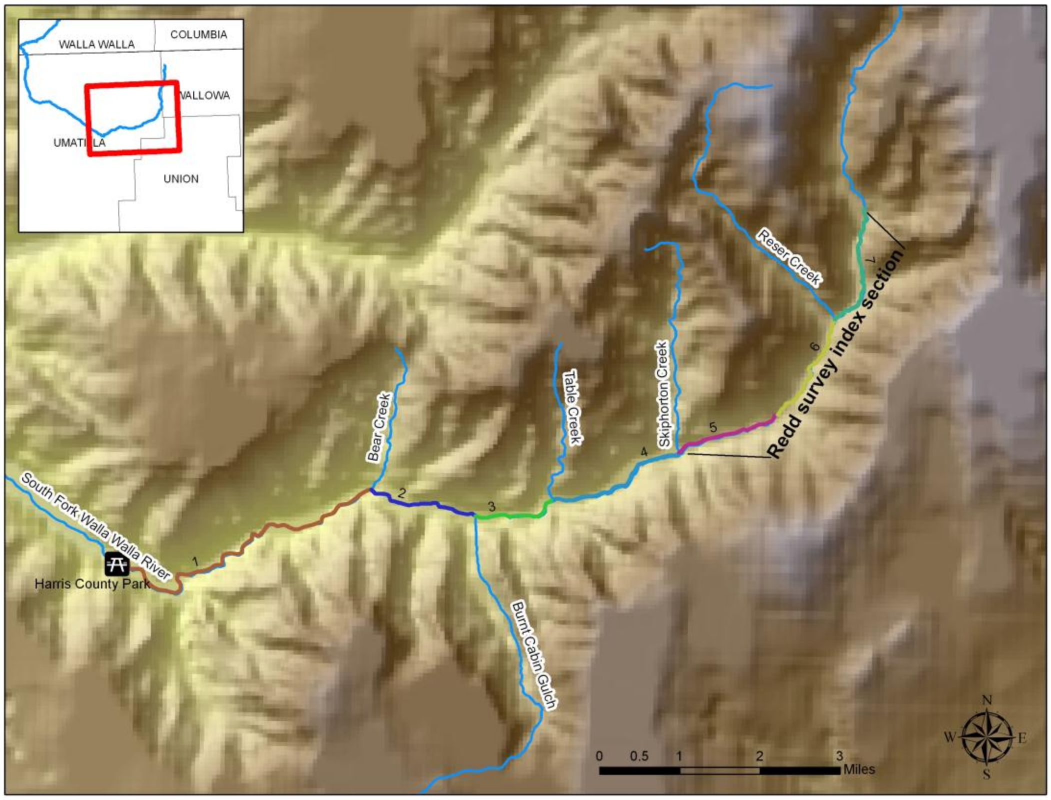

Figure 9. Map of the SFWWR redd survey area showing reaches 1 through 7, Reser Creek, and Skiphorton Creek where surveys are typically conducted. Surveys during 2005 were only conducted on reaches 5, 6, and 7.

Spawning Habitat Suitability Model

No Results or Discussion are included in this report regarding development of the spawning habitat model. Our methods are presented here to allow researchers to repeat this study in other areas. Fluvial and resident bull trout spawn in the headwaters of the SFWWR. During fall 2005, we measured microhabitat variables at bull trout redds and nearby locations that were not used for spawning every three weeks to obtain use and non-use data to develop a habitat suitability model for spawning bull trout. Microhabitat variables determine the suitability of any particular location on the stream bottom for a bull trout redd. Surrounding mesohabitat conditions may be important in some areas, but in the SFWWR where conditions are generally pristine, mesohabitat variables were continuous, uniform, and of good quality. As a result, we focused our data collection on microhabitat variables.

During fall 2005 we initiated a reconnaissance level groundwater-stream water interaction investigation to help determine if hyporheic exchange may be a factor in spawning habitat selection by bull trout in the SFWWR. We installed piezometers at 19 redds and 19 randomly selected non-use locations on September 29, 2005, in the stream reach 2.4 km below Reser Creek.

Due to the remoteness of the study area, we employed a methodology that utilized a dual-tube drilling system and minipiezometers to estimate vertical hydraulic gradient (Baxter et al. 2003). Slight modifications were made to the installation device design as described in Baxter et al. 2003. The outer casing was 194 cm in length and constructed from seamless ¾-in stainless steel schedule 40 pipe. The inner driving rod was a 114 cm length of solid cold-roll stainless steel (¾-in diameter) round bar ground to a point on one end. An 80 cm length of ¾-in pipe was securely welded around the top portion of the driving rod to serve as an attached striking cap. This modification was made to not only avoid carrying a separate hammer cap, but also to ensure a solid striking point for driving the rod and casing simultaneously into the substrate without damaging the device. The attached striking cap design also facilitated the removal of the driving rod from the casing during minipiezometer deployment.

The minipiezometers were 140 cm long and constructed from 5/8-in chlorinated polyvinyl chloride pipe that was perforated with 30 evenly spaced holes (hole diameter, 0.238 cm [3/32 in]) over the bottom 15 cm of its length and plugged with a cork at the bottom (Baxter et al. 2003). A stilling well, constructed from a 30 cm length of 5/8-in PVC (polyvinyl chloride) pipe was firmly attached to the downstream end of the minipiezometer with electrical tape to aid in obtaining accurate stream surface height measurements. Vertical hydraulic gradient was calculated by measuring the difference in head between the water level in the piezometer and the level of the stream surface using a Solinst Mini Water Level Meter. The sequential minipiezometer installation procedure is illustrated in Figure 10.

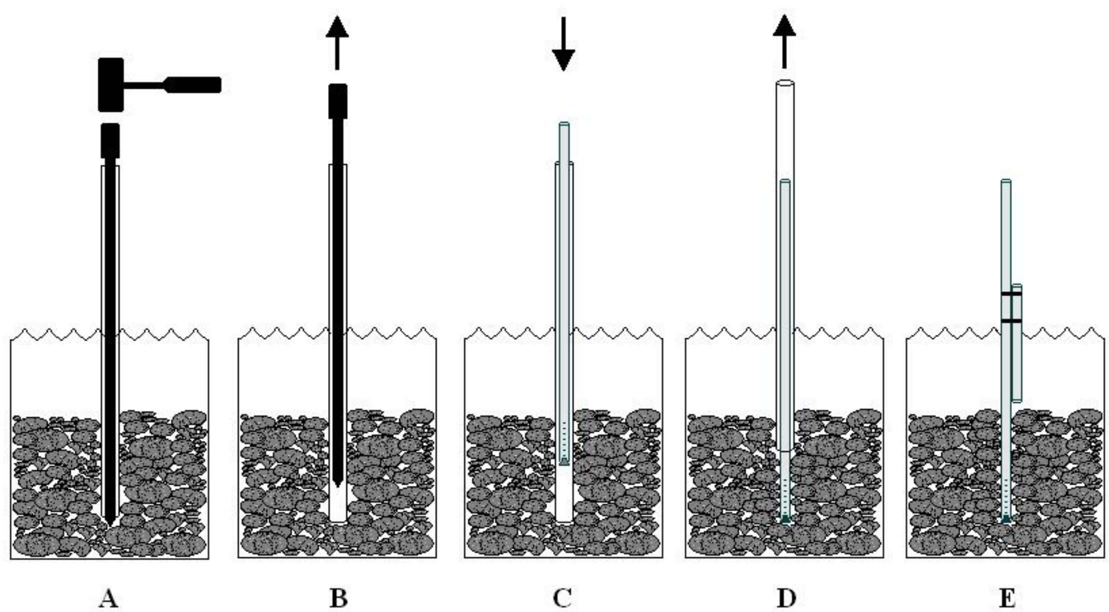

Figure 10. Sequential minipiezometer installation procedure. (A) The dual-tube drilling device (driving rod inserted into the steel casing) is hammered into the substrate. (B) The driving rod is removed, leaving the casing imbedded in the streambed. (C) The minipiezometer is inserted inside the casing. (D) The minipiezometer remains in place while the casing is removed from the substrate. (E) The stilling well is securely attached to the downstream side of the minipiezometer by vinyl electrical tape (adapted from Baxter et al. 2003).

Following installation, the piezometers were allowed to equilibrate and vertical hydraulic gradient measurements were collected at use and non-use locations on October 6, 2005. Vertical Hydraulic Gradients that were =0.0 cm, >0.0 cm and <0.0 cm were then categorized as neutral, upwelling or downwelling, respectively. We used logistic regression analysis (SAS ver. 9.1, 2003) to determine if groundwater was a significant factor in redd site selection.

Surveyors also measured the water depth, nose velocity, and mean column velocity at the upstream edge of the redd pit with a top-set wading rod and a Marsh-McBirney Flo-Mate Model 2000 flow meter. When measuring water velocities in eddies, the flow meter sensor was pointed directly into the current, just as a fish would be oriented (Rantz 1982). Surveyors then classified dominant and subdominant substrate size and percent fines at the redd. Substrate was categorized into six classes by diameter (Table 1), and percent fines was categorized into four classes (Table 2). Once data were collected at the use point (redd), a non-use point was determined by pacing a random distance (one to six steps upstream or downstream and one to six steps toward either stream bank) away from the redd where the measurements were repeated.

Table 1. Substrate types and particle sizes used to classify dominant and subdominant substrates for spawning bull trout.

Substrate Type	Particle size (cm)	Particle size (inch)
Sand	<0.64	<.25
Pebble	0.65 – 2.54	0.25 - 1.0
Small Gravel	2.55 – 5.08	1.0 - 2.0
Large Gravel	5.09 – 7.62	2.0 - 3.0
Cobble	7.63 – 15.24	3.0 - 6.0
Boulder	>15.24	>6.0

Table 2. Percent fines codes and classification descriptions for conditions at bull trout redd locations and adjacent non-use locations.

Code	Description
1	0 to 25 percent of visible substrate <0.64 cm
2	26 to 50 percent of visible substrate <0.64 cm
3	51 to 75 percent of visible substrate <0.64 cm
4	76 to 100 percent of visible substrate <0.64 cm

The methods described above were also used while collecting data during 2004. Data collected during 2004 and 2005 were then combined into one dataset. Analytical methods of this dataset included the development of a probabilistic model that could be used to predict the suitability of instream conditions for spawning bull trout. We used logistic regression analysis to determine the significance of individual microhabitat variables (univariate analysis) and to build and evaluate multivariate models for predicting bull trout spawning habitat. We used logistic regression because it is well suited for the examination of the relationship between a binary response (i.e., the presence or absence of redds) and various explanatory variables. Presumably smaller, resident bull trout construct smaller redds and potentially select different types of habitat. Following this logic, microhabitat data collected at small <0.5m, medium 0.5 - <1.0m, large 1.0 - <1.5 m, extra-large ≥ 1.5 m redds were separated. We then conducted a preliminary assessment of the habitat variables that were associated with each of the different sized redds using logistic regression techniques. We fit logistic models of the form:

$$\log_e\left(\frac{\pi(x)}{1-\pi(x)}\right) = \beta_0 + \beta_1 x_1 + ... + \beta_n x_n + \varepsilon \ ,$$

where $\pi(x)$ is the probability of redd deposition associated with habitat variables $x_1, x_2, ..., x_n$, and $\beta_0, \beta_1, ..., \beta_n$ are estimated model parameters (coefficients), and ε is a binomially-distributed error term. We fit logistic models using each habitat variable, one at a time, and measured the degree of model fit using Akaike's Information Criterion (AIC) (Burnham and Anderson 2002). Lower values for the AIC indicated better-fitting models. Following these univariate analyses, we developed multivariate models for each of the redd size classes, using the highest-ranking variables identified in the univariate analyses. The Z statistic was then calculated to test for differences between the models, where:

$$Zstatistic = \frac{Est_1 - Est_2}{\sqrt{SE(Est_1)^2 + SE(Est_2)^2}}$$

Where Est_1 and Est_2 are the variable estimates for the two size classes being tested and $SE(Est_1)$ and $SE(Est_2)$ are the variable estimate Standard Errors. Models developed from data collected at different size classes of redds that, when compared, showed no difference were combined into one data set and a logistic regression model was developed as previously described. The highest-ranking variables were added to the multivariate model until AIC values indicated that adding additional variables did not improve model fit.

The multivariate model was then balanced. To determine the best balanced model we focused on three accuracy statistics, overall model accuracy (number of correct predictions of redd presence and absence/total number of predictions), model sensitivity (percent of redd presence sites correctly classified) and model specificity (percent of redd absence sites correctly classified). Classification accuracy was examined at 3 cutpoints, 60%, 66% and 72% to find the best balance between correctly predicting redd occurrence and redd absence.

Rearing Habitat Suitability Model

No Results or Discussion are included in this report regarding development of the rearing habitat model. Our methods are presented here to allow researchers to repeat this study in other areas. Rearing bull trout occur both in the SFWWR and in the mainstem downstream at least as far as the WA/OR state line. We collected microhabitat and mesohabitat data at locations where rearing bull trout were found during our snorkel surveys to develop a rearing habitat suitability model. Habitat use and non-use data were collected monthly from July through November in the study area during 2005. Data were recorded when a bull trout was observed during snorkel surveys without being disturbed. Microhabitat data were recorded at each fish location and mesohabitat data were recorded for the habitat unit where the fish was observed, for example, in a race or pool.

Microhabitat Data Collection

When rearing bull trout were observed, snorkelers marked their location with a colored washer, estimated total length, noted any marks, and identified nose depth. Snorkelers finished surveying the habitat unit and then returned to the location of the bull trout to measure microhabitat variables. Once data were collected at the fish location, a non-use point was determined by pacing a random distance (one to six steps upstream or downstream and one to six steps toward either stream bank) away from the fish location where the measurements were repeated. Water depth and mean column velocity were recorded using a top-set wading rod and a Marsh-McBirney Flo-Mate Model 2000 flow meter. Dominant and subdominant substrate size and percent fines were classified for a 0.5 m square around the location of the fish and the non-use point. The same substrate and percent fines classes were used as previously described for spawning bull trout. Finally, cover type was determined by the type of cover present within 0.5 m of the fish location or non-use point (Table 3).

Table 3. Cover types and descriptions used to characterize cover conditions for rearing bull trout.

Cover type	**Description**
Turbulence	Present if we could not accurately detect substrate composition
Large Woody Debris	Debris must be 10 cm in diameter, 1 m in length and within 1 m of the water surface
Boulder-Juvenile	Boulder must provide a sheltered area at least 5 cm deep and 10 cm long
Boulder-Adult	Boulder must provide a sheltered area at least 10 cm deep and 40 cm long
Undercut Bank-Juvenile	At least 5 cm deep and 10 cm long
Undercut Bank-Adult	At least 10 cm deep and 40 cm long
Overhanging Vegetation	Vegetation that is within 0.5 m from the fish location and within 1 m from the stream surface
Debris Pile	Aggregation of 10 or more pieces of large woody debris
Other	Other types of physical structure such as bank stabilization material
No Cover	None of the cover types described above

Mesohabitat Data Collection

Four categories of data were also collected for each mesohabitat unit (pool, race) we sampled during snorkel surveys; water temperature, canopy cover, undercut bank, and cover type. First, water temperature was recorded at the downstream end of the habitat unit before snorkelers entered the water. Following the snorkel survey, the other three mesohabitat variables were characterized for the habitat unit. Canopy cover was described as the percent coverage of tree foliage overhanging the unit and was classified into five categories (Table 4).

Table 4. Canopy cover codes and classification descriptions for rearing bull trout mesohabitat.

Code	Description
1	No canopy cover
2	1 to 25 percent canopy coverage
3	26 to 50 percent canopy coverage
4	51 to 75 percent canopy coverage
5	76 to 100 percent canopy coverage

The amount of undercut bank in a unit was visually determined and classified into five categories (Table 5). The undercut bank had to be at least 5 cm deep, segments of undercut bank had to be continuous for at least 10 cm, and the cumulative total of the undercut segments was then classified into one of the five categories.

Table 5. Undercut bank codes and classification descriptions for rearing bull trout mesohabitat.

Code	Description
1	No undercut banks
2	1 to 25 percent undercut banks
3	26 to 50 percent undercut banks
4	51 to 75 percent undercut banks
5	76 to 100 percent undercut banks

Finally, eight cover types were recorded as present or absent in the unit. The cover types used were the same used for rearing bull trout microhabitat characterization (Table 3) with the exception of the two undercut bank cover types. Undercut banks were characterized for mesohabitat conditions as described previously and in Table 5.

No analysis of the rearing habitat suitability data was conducted because our efforts focused on developing a spawning habitat suitability model.

Stream Gage

Water quality and river stage monitoring was continued during 2005. Monitoring river stage was important for several reasons. Field work conducted to build our spawning habitat suitability model consisted of marking redd locations in the SFWWR during redd surveys, and returning at a later date to collect microhabitat data. Monitoring river stage assured that data collection was conducted under the same conditions that were present when the redds were constructed. In addition, monitoring river stage allowed us to determine the nature of instream working conditions for logistical planning. We continued to operate a Greenspan PS1200 pressure sensor had been deployed at Harris Park Bridge (rkm 97.0) on 4 September 2004 (Anglin et al. 2008) to measure and record river stage. The sensor was encased in PVC and anchored to the East bridge abutment. A correlating staff gauge was installed and surveyed into real elevations to visually confirm the accuracy of the pressure sensor. We also continued to operate a Greenspan CS4-1200 combination sensor that was installed on 4 September 2004 on the West bridge abutment at Harris Park Bridge to establish water quality conditions where the habitat is relatively pristine. The combination sensor measures temperature, dissolved oxygen, pH and electrical conductivity. Both sensors are linked via modem to the internet permitting river stage and water quality data to be automatically uploaded at 15 minute intervals to the Fish Passage Center website (www.fpc.org). Water quality data was verified monthly using an In-Situ Troll 9000 XP multi-parameter probe.

Results

Distribution

Snorkel Surveys

A total of 70 bull trout were observed during snorkel surveys conducted from July through November (Figure 11). The number of bull trout observed differed across months within study segments. In segment 2, the highest number of observations occurred during September (17), 13 occurred in July and August, six occurred in October and 10 occurred in November. In segment 1, no bull trout were observed during July through September, whereas eight were observed in October and three were observed in November. The number of bull trout observed also differed between segments within months. More bull trout were observed in segment 2 than in segment 1 during all months except October, when eight bull trout were observed in segment 1 and six were observed in segment 2.

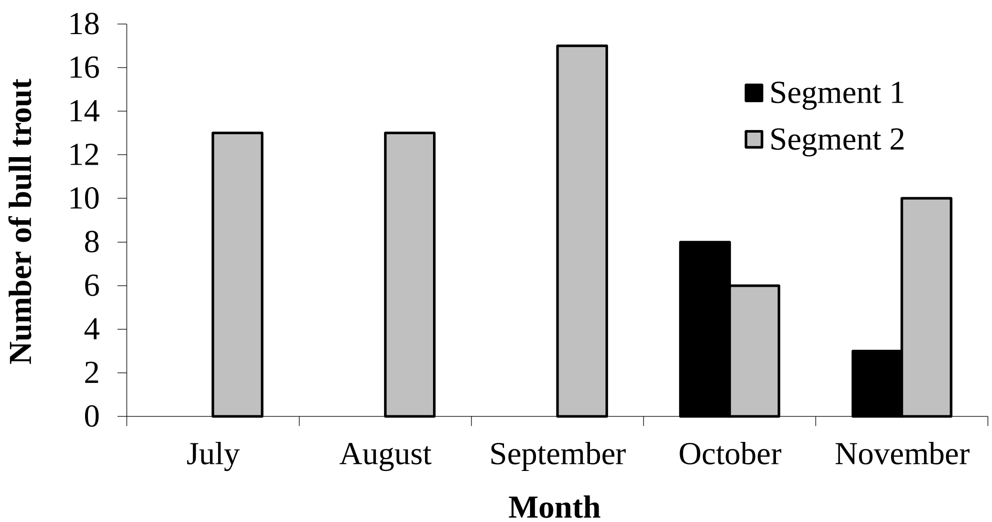

Figure 11. Total number of bull trout observed in each segment of the study area from July through November 2005.

No bull trout were observed downstream from NBD (rkm 74.3) from July to September during snorkel surveys. The downstream limits of observed bull trout during October and November were rkm 69.9 and 70.0, respectively. Estimated size of observed bull trout ranged from 100 to 550 mm. Fish in the 226 to 275-mm size class were most commonly observed (Figure 12).

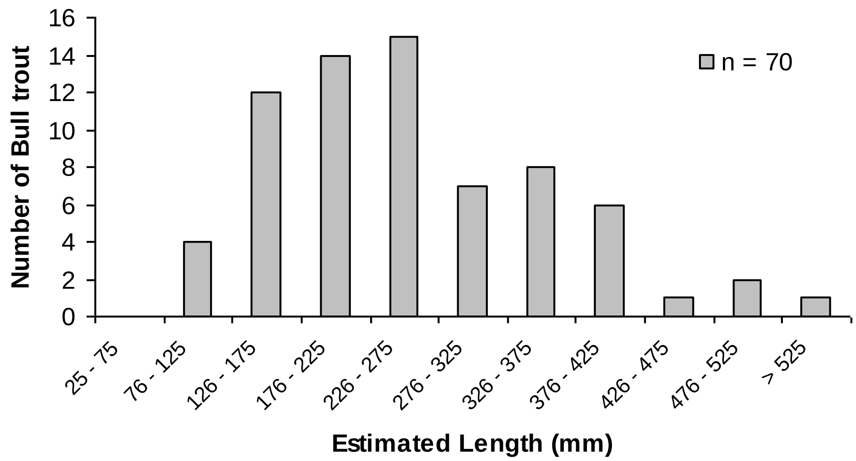

Figure 12. Length frequency histogram for bull trout observed during day snorkel surveys from July to November 2005.

A total of 47 bull trout were observed during snorkel surveys at the NBD monitoring site during 2005; 44 were likely subadult bull trout (≤ 325 mm) and 3 were likely adult bull trout (> 325 mm) (Table 6). The adult bull trout were observed during October and November surveys. Bull trout observed at the NBD monitoring site ranged in size from 150 to 450 mm, and the number observed during a single survey ranged from 2 to 24 fish.

Table 6. Total number of bull trout (n = 47) by size class and associated water temperature for each snorkel effort at the NBD monitoring site during 2005.

Month	**Water temperature (°C)**	**Average monthly temperature (°C)**	**Subadult bull trout (≤ 325)**	**Adult bull trout (> 325)**
July 22	15.4	16.8	4	0
August 13	13.9	16.2	2	0
September 17	10.4	NA*	4	0
October 7	9.0	NA*	12	1
November 16	6.0	NA*	22	2

NA* = No data

A total of 7,731 Chinook salmon and 9,896 *O. mykiss* were observed during the five months that snorkel surveys were conducted. Chinook salmon and *O. mykiss* in the 25 to 75 mm size class were most commonly observed (Figure 13). Monthly Chinook salmon and *O. mykiss* observations per square meter sampled from July through November 2005 are summarized in Figure 14. In general Chinook salmon and *O. mykiss* densities fluctuated during July through October, but decreased during November.

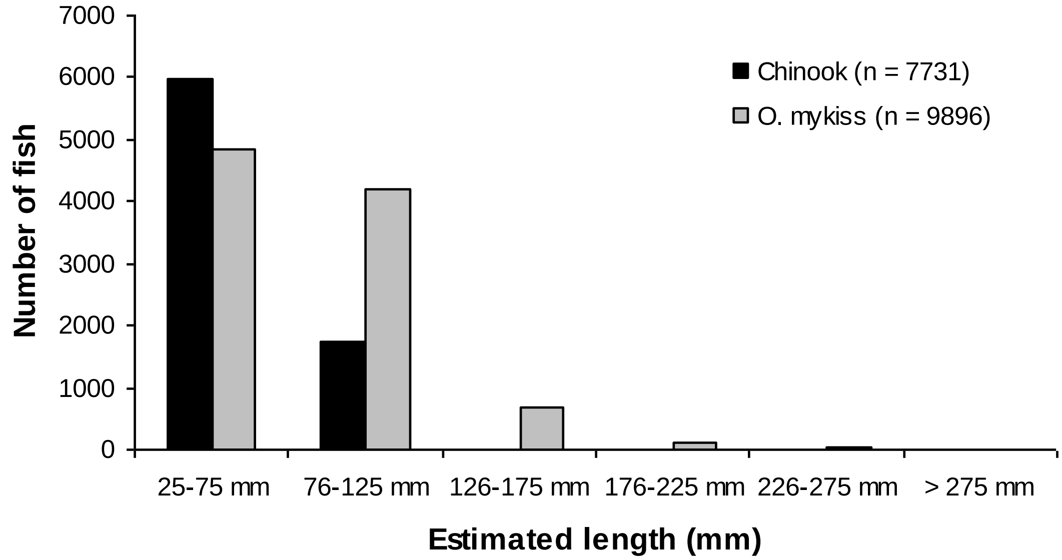

Figure 13. Length frequency histogram for Chinook salmon and *O. mykiss* observed during day snorkel surveys from July to November 2005.

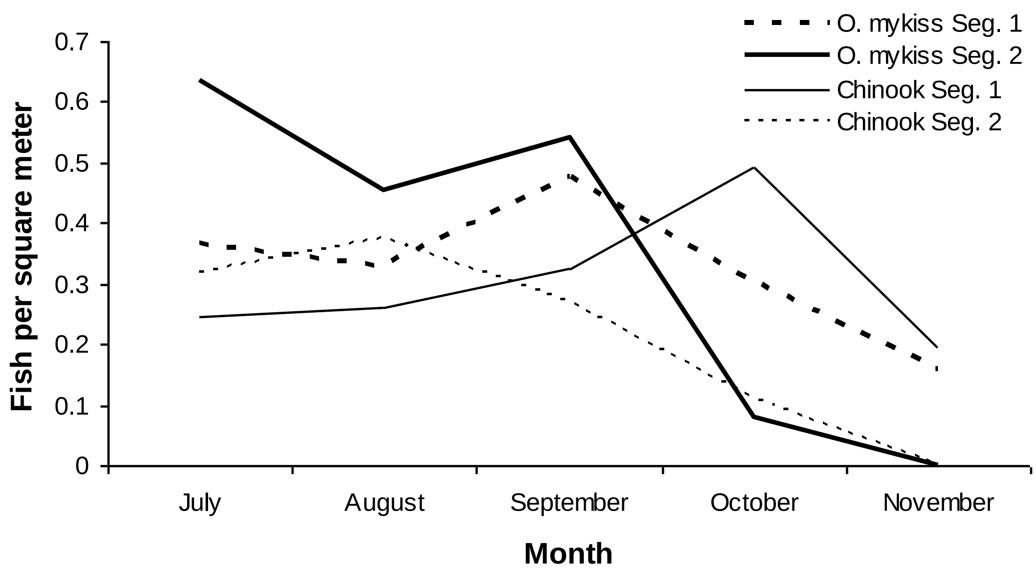

Figure 14. Monthly Chinook salmon and *O. mykiss* observations per square meter sampled from July through November 2005.

Water Temperature

Average water temperatures generally increased in a downstream direction. Figure 15 shows the average temperature gradient during August in the SFWWR and throughout the study area.

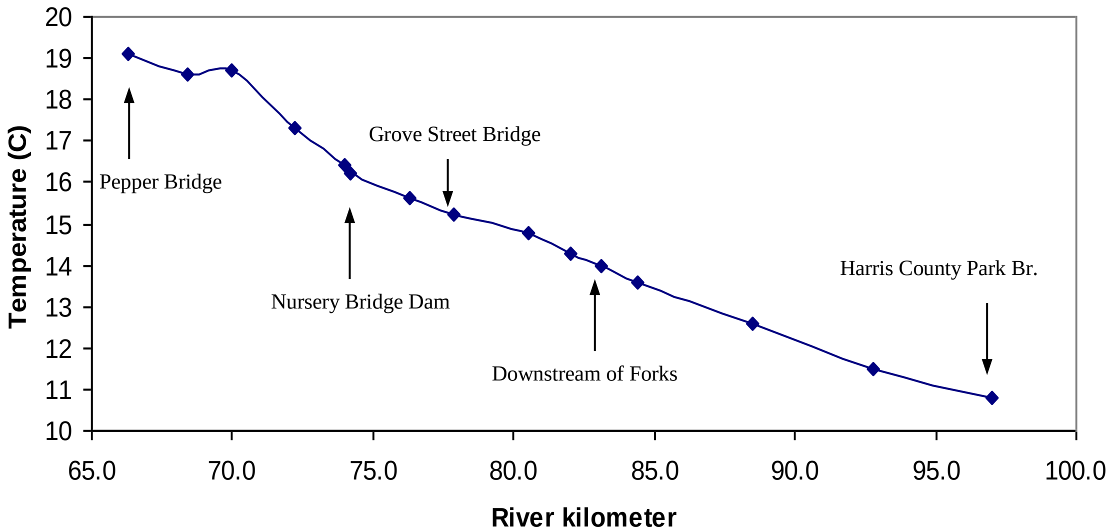

Figure 15. Average daily water temperature at 15 thermograph locations during August 2005. Blue diamonds represent thermograph locations. Several additional locations are labeled on the graph for reference.

Average daily minimum, maximum, and mean water temperatures in the study area are shown in Table 7 by segment and month. July and August are the warmest months in all segments. Water temperature increases are the largest between segments 2 and 1 during August, presumably as a function of the reduction in streamflow between these segments. The difference between average daily minimums and maximums is greater in segment 1 compared to the upstream segments. The data suggest that the primary cause of this difference is relatively higher daily maximums in segment 1, again, likely because of the increased heating effect of solar radiation on both the reduced volume of water in this segment and on the substrate due to shallow water depths. A detailed summary of average daily minimum, average, and average daily maximum temperatures by month (January – December 2005) is presented in Appendix A.

Table 7. Average daily minimum, average daily maximum, daily mean and water temperatures by segment from thermograph data.

		Month				
Segment		**July**	**August**	**September**	**October**	**November**
	Min	13.3	12.5	10.2	8.6	5.0
2	Mean	15.5	14.8	11.5	9.4	5.5
	Max	18.1	17.2	13.1	10.3	6.1
	Min	15.2	14.9	11.6	9.5	5.1
1	Mean	18.2	17.7	13.7	10.8	5.9
	Max	22.1	21.3	16.5	12.6	6.7

Movements

Rotary Screw Trap

The rotary screw trap at Joe West Bridge captured 19 bull trout, 13 of which we PIT tagged. Length frequencies of the 19 bull trout captured while operating the screw trap are presented in Figure 16. Of the 19 bull trout caught, 18 were likely subadult fish (≤ 325 mm) and one was a larger adult fish (> 325 mm). Fork length of bull trout captured ranged from 109 to 555 mm and averaged 188 mm.

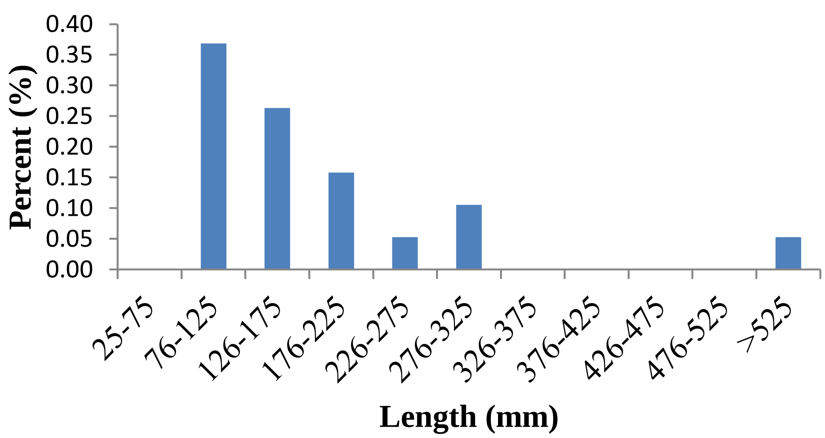

Figure 16. Length frequency histogram of 19 bull trout captured in the screw trap from January through June, 2005.

Low bull trout recaptures provided insufficient data to assess the magnitude of the migration past the Joe West Bridge trap site. Captures of bull trout suggest migration or dispersal of bull trout occurred during January through April (Figure 17). No bull trout were captured during May or June but sampling did not occur during May and was limited to 9 days during June. Bull trout captures were higher in April than in any other month sampled in 2005.

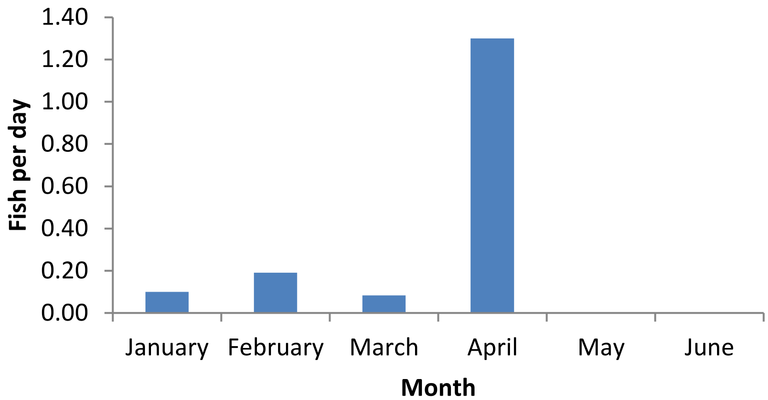

Figure 17. Average number of bull trout captured per day while operating a screw trap at Joe West Bridge during 2005. The screw trap sampled 10, 21, 24, 13, 0, and 9 days during January, February, March, April, May, and June, respectively.

Length-frequency distribution analysis indicated three distinct length-groups of Chinook salmon captured by the screw trap during the trapping period at this site. Most Chinook salmon that migrated at < 40 mm were captured from January through April, Chinook that migrated at > 40 mm < 70 mm were captured in June, and Chinook migrating at > 70 mm were captured primarily from mid-January through April (Figure 18).

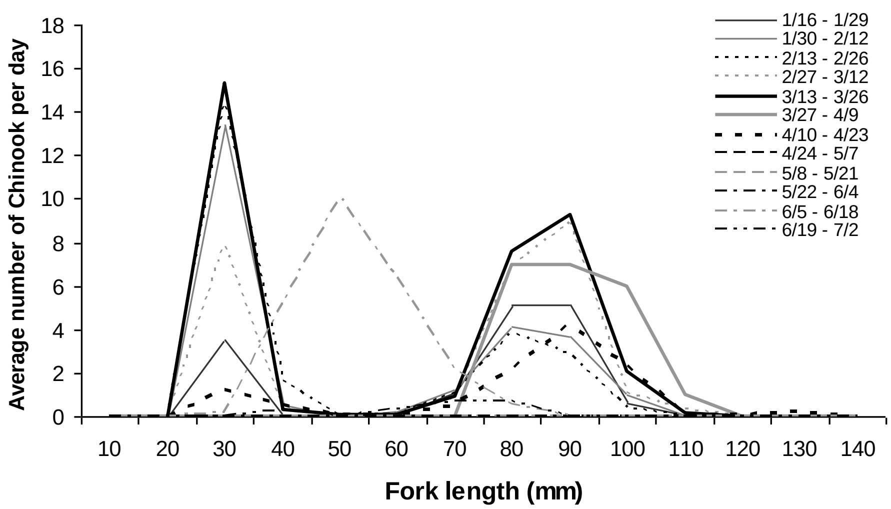

Figure 18. Fork lengths and average number of Chinook salmon captured per day at the Joe West Bridge trap site separated into 2 week intervals during 16 January through 2 July, 2005.

Length frequency analysis of *O. mykiss* captured showed three length-groups migrating past the trap. Analysis of length frequency data suggests differing migration times for the size groups of *O. mykiss*. Most *O. mykiss* > 110 mm were captured primarily mid-March to late

April. *O. mykiss* > 50 mm and < 110 mm were captured predominantly during January and late April, but were captured throughout the season. *O. mykiss* < 50 mm were mostly captured in June (Figure 19).

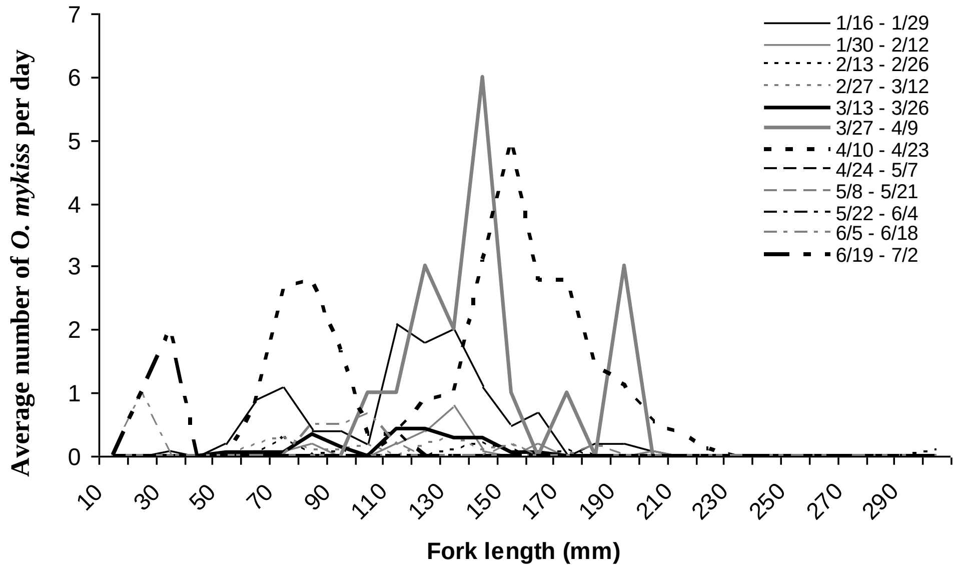

Figure 19. Fork lengths and average number of *O. mykiss* captured per day at the Joe West Bridge trap site separated into 2 week intervals during 16 January through 2 July, 2005.

PIT Tag Detection Arrays

Fifty-six bull trout, 39 Chinook salmon and one *O. mykiss* were observed at the WW1 PIT tag detection array (Table 8). Bull trout detected at WW1 ranged in size from 126 to 608 mm when initially PIT tagged. Adult bull trout moved upstream primarily during May through July and downstream primarily from September through November (Budy et al. 2006). Subadult bull trout dispersed downstream throughout the year with an initial pulse in the spring and a larger pulse in August.

Table 8. Total number of detections by species at each antenna site in the SFWWR, WWR and Mill Creek in 2005.

	Number of detections			
Antenna site	**Bull trout**	**Chinook salmon**	***O. mykiss***	**Coho**
ORB	0	46	74	1
NBD	13	370	45	0
WW1	56	39	1	0
MCD	25	96	17	0

Total individual detections at the NBD detection array were 13, 45, and 370 for bull trout, steelhead and Chinook salmon, respectively (Table 8). Bull trout detected ranged in size from 130 to 519 mm when initially PIT tagged. Of the 13 bull trout detected at NBD, five were adults. Detection histories for the adult bull trout suggest upstream movement in May and June and downstream movement during October, November and March (Figure 20). Of the 13 bull trout detected at NBD, eight were subadults. Two subadult bull trout dispersed downstream during May and July and the remaining six subadult bull trout dispersed past NBD during January and October through December 2005. The single fish detected at NBD in January was also detected in February. The highest movement activity occurred during the months of May and November.

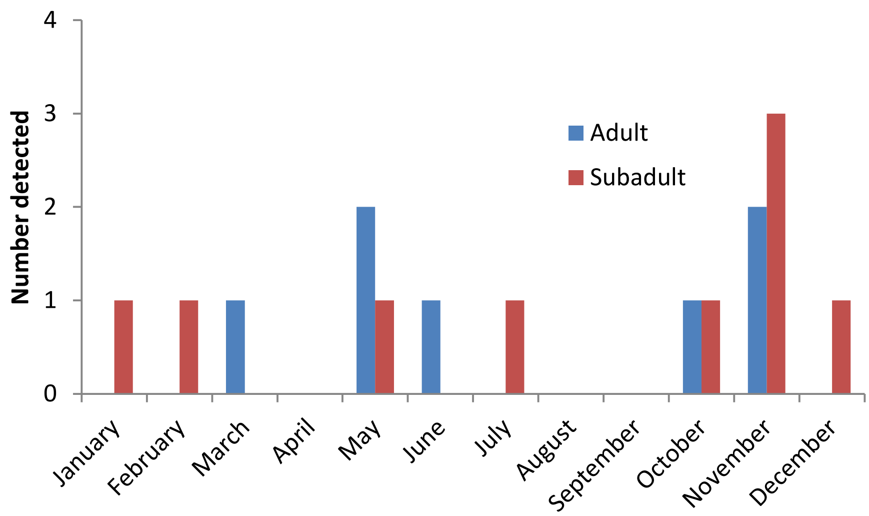

Figure 20. Monthly PIT detections of adult and subadult bull trout at NBA during 2005.

Total individual detections at MCD were 25, 17, and 96 for bull trout, steelhead, and Chinook salmon, respectively (Table 8). Bull trout detected ranged in size from 120 to 479 mm when initially PIT tagged. All fish detected at the MCD tag detection array were tagged and released in Mill Creek upstream of the array. Eleven of the bull trout detected at MCD were adults. Detection histories for these fish suggest upstream movement occurred during April and May 2005 (Figure 21). The single bull trout detected at MCD in March was also detected in April. Only two adult bull trout were detected moving downstream past MCD, and that occurred during October and November 2005. Fourteen bull trout detected at MCD were subadults. Twelve of them were detected dispersing downstream past MCD during April through June 2005 and two were detected dispersing downstream during October and December 2005. The highest number of individual bull trout detections at MCD occurred during May, when 11 were detected. No returning adult Chinook salmon or steelhead were detected.

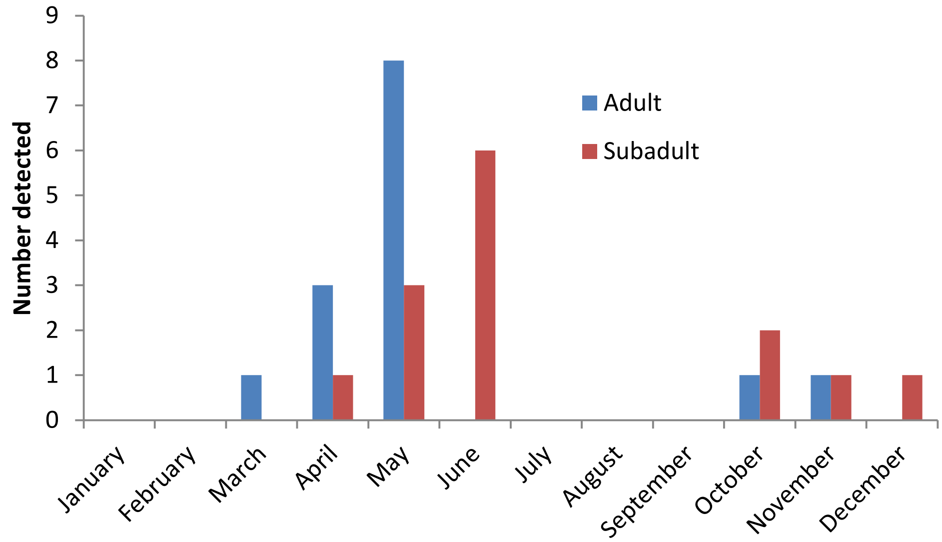

Figure 21. Monthly PIT detections of adult and subadult bull trout at MCD during 2005.

No bull trout were detected at ORB during 2005. Total individual detections at ORB antenna were 1, 46, and 74 for Coho, Chinook salmon and steelhead, respectively (Table 8). Fish detected at the ORB antenna were tagged in the WWR, Lyons Ferry Hatchery, or Cle Elum Hatchery and were released in the WWR, Touchet River, Mill Creek or the Clark Flat Acclimation Pond. One Chinook salmon tagged in the SFWWR as a smolt in 2002 was detected returning as an adult in 2005.

Bull trout PIT tagged in the Walla Walla Basin have the opportunity to be detected at PIT detection arrays at dams in the Columbia River. No bull trout were observed at Priest Rapids Dam, McNary Dam and Ice Harbor Dam adult fish counting facilities during 2005.

PIT tag detection array operation can affect the number of detections and should be considered when interpreting patterns observed in detection data. The number of days of operation and downtime for all PIT tag detection arrays are reported in Table 9.

Table 9. System operation and downtime for PIT tag detection arrays in the Walla Walla Basin during 2005.

Antenna site	System operation (days)	System downtime (days)
ORB	157	29
NBD East ladder	365	0
NBD West ladder	170	0
WW1	354	11
MCD	309	0

Detection efficiency ranged from 22 to 100% for 23-mm tags, and 0 to 100% for 12-mm tags at the NBD ladder antennas (Table 10). Detection efficiency averaged 92% for 23 mm tags at the East and West bank ladder antennas. Average detection efficiency at the East and West bank ladders was 49% and 0%, respectively. Array evaluations results differed dramatically between 12- and 23-mm tags and individual antennas. Overall, 23-mm tags were consistently detected and 12-mm tags were not.

Table 10. Efficiency test results for the NBD East and West PIT tag detection arrays during 2005. NM = not measured.

	East Bank Ladder PIT Tag Efficiency Test Results (%)										
PIT tag size (mm)	**Jan**	**Feb**	**Mar**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
12	30	30	0	100	11	0	22	100	99	100	49.2
23	100	100	100	100	22	100	100	100	100	100	92.2
	West Bank Ladder PIT Tag Efficiency Test Results (%)										
PIT tag size (mm)	**Jan**	**Feb**	**Mar**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Average**
12	0	0	0	0	NM	NM	NM	NM	NM	NM	0
23	100	90	90	90	NM	NM	NM	NM	NM	NM	92.5

Detection efficiency at MCD ladder antennas was 100% for 23-mm tags from July through December 2005 (Table 11). Detection efficiency ranged from 58 to 100% for 12-mm tags during the same time period. Average detection efficiency was 85% for 12-mm tags. Overall, both 12- and 23-mm tags were consistently detected at MCD ladder antennas.

Table 11. Efficiency test results for the MCD PIT tag detection array during 2005.

	Downstream Ladder Antenna PIT Tag Efficiency Test Results (%)						
PIT tag size (mm)	**July**	**August**	**September**	**October**	**November**	**December**	**Average**
12	100	100	58	100	50	100	85
23	100	100	100	100	100	100	100
	Upstream Ladder Antenna PIT Tag Efficiency Test Results (%)						
PIT tag size (mm)	**July**	**August**	**September**	**October**	**November**	**December**	**Average**
12	100	100	100	100	100	100	100
23	100	100	100	100	100	100	100

Detection efficiency ranged from 19 to 98% at the ORB PIT detection array during 2005 (Table 12). Detection efficiency was relatively low (≤22%) during April and May, when only one antenna was installed. Detection efficiency increased to 53% during June, when 3 additional antennas were installed. Detection efficiency was relatively high (≥74%) during August through December. Detection efficiency decreased from 98% in November to 86% in December when high streamflows damaged four of the six antennas leaving only the two bank antennas operational.

Table 12. Percent area monitored for individual antennas and average monthly percent detection efficiency at the ORB PIT detection array. NP=antennas were damaged or not present.

	Antenna						
Date	**1**	**2**	**3**	**4**	**5**	**6**	**Detection Efficiency**
Apr-05	NP	NP	NP	NP	NC	NP	22%
May-05	NP	NP	NP	NP	NC	NP	19%
Jun-05	NP	100%	100%	100%	100%	NP	53%
Jul-05	NP	100%	100%	100%	100%	NP	67%
Aug-05	NP	100%	100%	100%	100%	NP	95%
Sep-05	NP	100%	NP	100%	100%	NP	74%
Oct-05	NP	100%	100%	100%	100%	NP	77%
Nov-05	NP	97%	90%	100%	100%	NP	98%
Dec-05	100%	100%	100%	100%	100%	100%	86%

Habitat Suitability

Redd Surveys

The 2005 redd surveys for the index reach of the SFWWR were conducted by ODFW and FWS on 26 September and 17 October 2005. The cumulative number of bull trout redds enumerated over two surveys was 170.

Spawning Habitat Suitability Models

Although spawning habitat suitability data was collected during 2005, no results are reported. Our efforts focused on producing a peer reviewed journal article.

Rearing Habitat Suitability Models

Although rearing habitat suitability data was collected during 2005, no results are reported. Our efforts focused on developing a spawning habitat suitability model.

Stream Gage

Streamflows (i.e. river stage) in the SFWWR varied throughout the year at Harris County Park Bridge. Warm weather in January caused a snow melt event. The spring freshet occurred from late March through June and the onset of base flows occurred during July. Streamflows were relatively steady at base flow (~90 cfs) throughout the bull trout spawning season during September and October. Rain events produced increases in streamflow and the corresponding river stage during November and December (Figure 22). River stage ranged from 1,974.07 to 1,976.60 feet and averaged 1,974.84 feet during this twelve month sampling period.

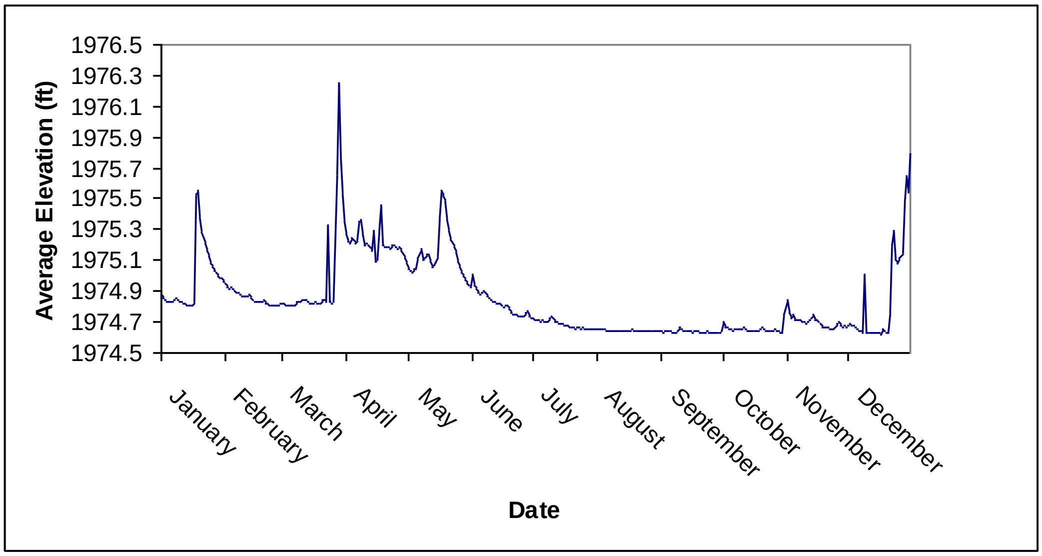

Figure 22. Daily average water surface elevation at the Harris County Park Bridge stream gage from January through December 2005.

Water quality parameters recorded at Harris Park Bridge in the SFWWR are reported in Table 13.

Table 13. Minimum, maximum and average values for water quality data collected at Harris Park Bridge in the SFWWR from 1 January 2005 to 31 December 2005.

Water Quality Parameter	Minimum	Maximum	Average
Temperature (°C)	0.43	11.74	6.87
pH	6.87	8.78	7.45
Dissolve Oxygen (ppm)	5.6	11.0	9.7
Electrical Conductivity (mS/cm)	9.1	92.4	52.2

Discussion

Distribution

Snorkel Surveys

Determining the spatial and temporal distribution and relative abundance of bull trout in the WWR from the forks to the OR/WA state line is instrumental in understanding the habitat and instream flow needs for bull trout in this section of the river. Many studies have stressed the need for accurate distribution and habitat use information in drainages where bull trout reside (e.g., Banish 2003; Mendel et al. 2001). These types of data are required at various spatial scales to understand the life history requirements and habitat needs of bull trout, and to focus restoration efforts that improve those attributes that are important to bull trout.

We conducted our snorkel surveys to address two specific questions regarding distribution: 1) Is the number of bull trout different among segments within each month considering the different physical conditions among the segments? and 2) Does the number of bull trout within a segment change across months as physical conditions change? More bull trout were observed in segment 2 than in the segment 1 during all months except October, when counts were similar. Considering our study area segments were designated to coincide with changes in physical conditions in the WWR, these results were not surprising. Base streamflows are relatively consistent in segment 2 (~90 cfs). Base streamflows are substantially lower in segment 1, primarily from June through October (Figure 23) as a result of irrigation diversions at the Little Walla Walla Diversion. Streamflows range from about 10 to 25 cfs in segment 1 throughout the summer. This flow level in the WWR limits fish passage as well as the available habitat (i.e. physical living space), and contributes to elevated water temperatures.

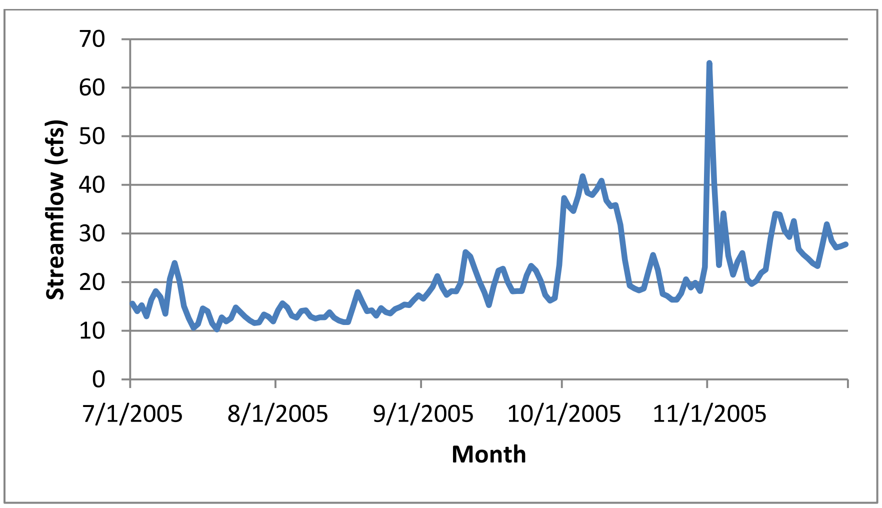

Figure 23. Streamflow measured in 2005 at the Washington Department of Ecology Pepper Bridge stream gage just downstream from the OR/WA state line on the WWR.

Water temperatures increase in a downstream pattern through the study area, becoming less suitable for bull trout. During the months of July through September, mean water temperatures range from approximately 12-16 ° C in segment 2 and from 14-18 ° C in segment 1 (Figure 24). Warmer temperature together with the large reduction in streamflow and poor quality mesohabitat conditions in segment 1 produce conditions that are marginal for bull trout. Limited physical habitat as a result of low streamflows, high water temperatures resulting from low streamflows, lack of continuous riparian cover, reduced groundwater inflow, and poor mesohabitat conditions all likely contribute to the reduced abundance of bull trout in segment 1 compared to segment 2.

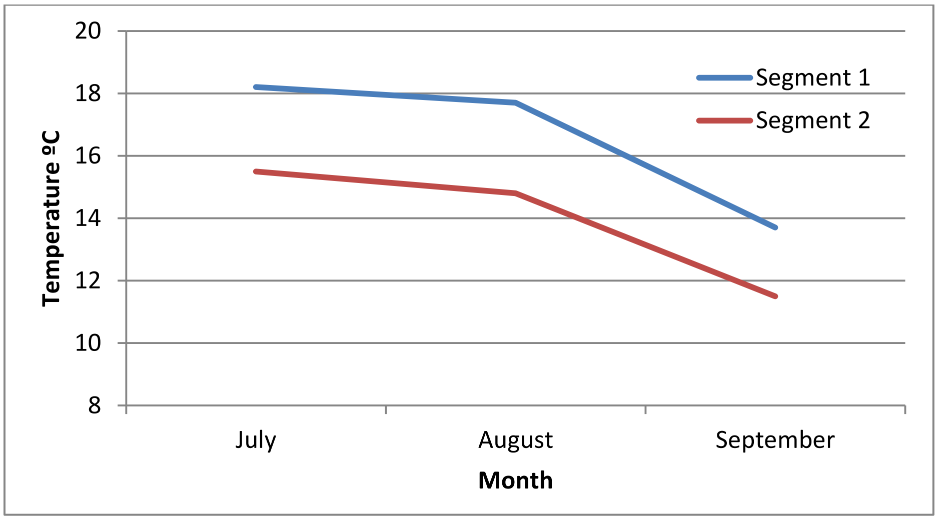

Figure 24. Mean monthly water temperature measured in 2004 at thermograph locations in study area segments 1, and 2 on the WWR.

Differences in abundance of bull trout were observed within each of the segments across all months. Although there were differences in bull trout abundance in segment 2, bull trout were present during each month. Streamflows were consistent in this segment, and water temperatures, although not ideal, were tolerable, thus the consistent abundance of bull trout. Differences in abundance of bull trout were most evident in segment 1. No bull trout were observed during July through September, whereas 8 were observed in October and 3 were observed in November. The increased numbers of bull trout during October and November were likely the result of higher streamflows and cooler temperatures during those months.

Bull trout were observed at the NBD monitoring site during July through November. Bull trout observations averaged 3.33 fish per survey from July to September, but increased dramatically in October and November to 13 and 24 fish respectively. Because of the inordinate fish counts at NBD, it was not included in distribution analyses, and therefore did not misleadingly represent fish distribution in segment 1 of our study area. It is currently unknown why NBD pool attracted such high numbers of bull trout when compared to other pools throughout our study area. When water temperatures are high during the summer, bull trout may seek out larger, deeper pools that maintain slightly lower daily maximum water temperatures. Thermal stress can occur when water temperatures reach a threshold that produces significant changes to biological functions (McCullough et al. 2001). Since the larger, deeper pool at NBD exhibits slightly lower maximum daily water temperatures compared to surrounding areas, bull trout may reside there rather than moving farther downstream or upstream. It is unknown why there were such dramatic increases during October and November when the average monthly temperature just downstream from Nursery Bridge was 10.0 °C and 5.5 °C respectively.

Water Temperature

Numerous studies have shown that bull trout are sensitive to temperature, which can affect and ultimately determine distribution (Shepard et al. 1984; Goetz 1989; Fraley and Shepard 1989). Thermograph data revealed that water temperature increased incrementally from Harris Park (0.24 °C/km) in a downstream direction and did not expose any evident deviations from this trend until NBD. Data showed a rate of increase of 0.60 °C/km in water temperature between NBD (rkm 74.3) and Tumalum Bridge (rkm 70.4) and then a slight rate of decrease between Tumalum Bridge and the thermograph located 1.6 rkm downstream. There is a prominent seep approximately 150 m upstream of the thermograph which could be the reason for the slightly cooler temperatures at this location. Water temperature increased between Tumalum Bridge and Pepper's Bridge (rkm 66.3) at a rate of 0.12 °C/km. Bull trout downstream distribution was not lower than NBD (rkm 74.3) until November in 2004. Four bull trout were observed 4.3 km downstream of NBD in October 2005. One explanation for this occurrence could be that average water temperatures were cooler in 2005.

Significant habitat alterations such as irrigation diversions, levee construction and riparian habitat removal have occurred in segment 1and have likely contributed to warmer water temperatures in that lower segment. No habitat modifications of that degree occur in segment 2. The effect of these modifications on water temperatures can be observed in Figure 24 and Table 7.

Movements

Rotary Screw Trap

The ability of a five-foot rotary screw trap to be utilized as an effective bull trout sampling tool in inclement river conditions where other methods prove imprudent was demonstrated in 2004 and again confirmed during the 2005 trapping season. The degree of effectiveness depended primarily upon the ability of the screw trap to efficiently capture sub-adult bull trout. Relatively few (n = 19) bull trout were captured with the screw trap. Similar to results from the 2004 trapping season, low bull trout recaptures provided insufficient data to assess the magnitude of the migration past the Joe West Bridge trap site. It is unclear whether the screw trap configuration inefficiently caught bull trout or if the migration of sub-adults past the trap during the trapping period was small. Sub-adult bull trout behavior during downstream migration is largely unknown; however, rearing studies have indicated that older juveniles and adults are primarily bottom dwellers and often are associated with coarse substrates such as large cobbles and boulders (Fraley and Shepard 1989). Our snorkel surveys conducted in July to November 2005 showed an average nose depth of 7.5 cm for undisturbed rearing bull trout in pools and races. The association between bull trout and the stream bottom may have contributed to low sub-adult bull trout captures by the screw trap at the Joe West Bridge trap site.

Screw trap operations during 2005 provided useful sub-adult bull trout movement information. Bull trout were detected moving downstream from January through April. Screw trap operations suggest an increased downstream movement in April, but monthly trap efficiency was not estimated, so conclusions drawn from comparisons between months are limited. Screw trap data from 2004 showed increased downstream movement from mid-May to June. The screw trap may have missed downstream movement of bull trout during May 2005 when it was not operated due to high flows and personnel limitations. Comparisons to data collected from similar studies are limited. Hemmingsen et al. (2002) found that downstream movement of smaller bull trout on Mill Creek occurred year-round, but they operated a screw trap much closer to the known spawning area. Although sample size was relatively small, Budy et al. (2004) suggest 120-320 mm bull trout (likely subadults) moved downstream of Harris Park (rkm 97.0) from July to November while bull trout >320 mm (likely adults) moved in to spawn.

Length frequency data for Chinook salmon indicated fish <40mm migrated from January through March. Chinook salmon <70 mm and >40mm migrated during June. The Chinook salmon observed during January through March and June were likely young-of-year (YOY) or in the 0+ age category. The average number of fish observed decreased during April and May and was likely due to limited sampling. The trap sampled for 13 days during April and did not sample during May. Chinook salmon >70 mm were captured primarily from January through April were likely 1+ fish. This migration timing and dispersal is consistent with the description of Chinook salmon life history summarized by Healey (1991). *O. mykiss* <50 mm observed primarily during June were likely YOY or in the 0+ age category. *O. mykiss* >50mm were detected from January through April and were likely in the 1+ or 2+ age category. Comparisons between capture periods or size classes are limited because trap efficiency was not estimated.

A screw trap will not be utilized at the Joe West Bridge trap site in 2006 due to low bull trout captures during both 2004 and 2005. Additionally, CTUIR biologists no longer require the use of this screw trap location for Chinook salmon and *O. mykiss* smolt tagging activities.

<u>PIT Tag Detection Arrays</u>

In 2005, five adult and eight subadult bull trout were detected at the NBD detection array. Detection histories for the adult bull trout suggest upstream movement in May and June and downstream movement during October, November and March, which corresponds with spawning and over-wintering migration time periods. Subadult bull trout dispersed downstream during January, May, July and October through December 2005. Subadult bull trout were not observed dispersing downstream during August and September, when streamflows are generally low and temperatures relatively warm. Peak movements occurred during May and November when both adults and subadults were passing the array. The ability of the detection array to detect PIT tagged fish should be considered when interpreting detection results. There are three fish passage routes at NBD. Fish may pass through the East bank Ladder, the West bank ladder or over the spillway. At NBD only the ladders were monitored. During periods of higher flow, which generally occurs during winter and spring, fish can pass downstream over the spillway or jump over the spillway when moving upstream and would not be detected by the PIT array. Therefore, the number of detections reported during the winter and spring is likely an underestimate. In the ladders, two factors determine the efficiency of the PIT array to detect PIT-tagged bull trout, site functionality and detection probability. The NBD detection array was functional and did not have any system downtime. Detection efficiency evaluations performed on the ladder antennas suggest that on average 92% of the fish tagged with 23-mm PIT tags were detected at the array. When bull trout are restricted to moving through the NBD ladders, which generally occurs during summer and fall, they are likely to be detected.

In 2005 11 adult and 14 subadult bull trout were detected at the MCD detection array. Detection histories for the adult bull trout suggest upstream movement in April and May and downstream movement during October and November, which corresponds with spawning and over-wintering migration time periods. Subadult bull trout dispersed downstream during April through June, October and December. Subadult bull trout were not observed dispersing downstream during July through September, when streamflows are generally low and temperatures relatively warm. PIT tag detection array operation and performance can affect the number of detections and should be considered when interpreting movement patterns observed in detection data. The site was operational from 25 February through 31 December 2005. As a result, bull trout movements at the MCD detection array are unknown during January and most of February. There are three fish passage routes at MCD, over the spill way, through the low flow outlet and through the ladder. At MCD only the ladder and low flow outlet were monitored, the spillway was not. Spill at MCD typically only occurs when stream discharge exceeds 400 cfs. During 2005, flows exceeded 400 cfs only on 28 March, so it is likely relatively few fish passed over the spillway undetected. In the low flow outlet and the ladder, two factors determine the efficiency of the PIT array to detect PIT-tagged bull trout, site functionality and detection probability. In the low flow outlet, an antenna was operational from March through June, but it performed poorly. As a result, PIT tagged bull trout may have passed downstream undetected, particularly during the winter and spring when the low flow outlet usually passes a larger amount of water. Due to high velocities in the low flow outlet channel it is unlikely that bull trout moving upstream passed the facility using this route and would have been relegated to using the fish ladder. At least one antenna was functioning in the MCD fish ladder from 25 February through 31 December 2005. Although antenna efficiency tests at MCD didn't begin until July, results consistently suggest most PIT tagged fish passing MCD via the ladder would be detected. In general, from June through October, fish only pass MCD through the ladder because the low flow outlet is closed. In summary, it is likely that the number of detections reported during summer and fall is accurate, but the number of detections reported during winter and spring is likely an underestimate.

Although the number of individuals detected is relatively small, detections at the MCD array in Mill Creek show a pattern of movement that is consistent with data collected at the NBA array in the WWR. Detection histories suggest adult bull trout move upstream in the spring and downstream primarily during fall. Subadult bull trout dispersed downstream during spring and fall.

No bull trout were detected at the ORB PIT detection array during the sampling period. Untagged bull trout could have passed the array at any time and PIT tagged bull trout could have passed the array undetected, particularly during time periods when detection efficiency was relatively low. Although the Oasis Road Bridge antenna did not detect any bull trout during 2005, the site provided valuable migration data on other wild and hatchery salmonids in the Walla Walla Basin.

Habitat Suitability

Redd Surveys

In 2005 redd surveys were only conducted twice and only in reaches 5 through 7 due to a forest fire. The total number of redds enumerated in reaches 5 through 7 were down slightly from 2004 to 2005. In 2004, 198 redds were enumerated whereas in 2005, 170 redds were enumerated. Redd surveys are typically conducted every 2-3 weeks beginning as early as late-August and ending as late as early-November. When redds are created, the gravel is displaced and the exposed surface of the displaced gravel is typically clean of algae. When surveys are conducted every 2-3 weeks, clean gravel can be used as an indicator of redd construction. It is unknown whether the decrease in the number of redds observed during 2005 is actual or if redds were “missed” because of the limited frequency and timing of the surveys during 2005.

Stream Gage

The stream gage was successfully operated to monitor flows in the SFWWR during the spawning season and to determine the nature of instream working conditions for logistical planning. Water quality data collected from January to December of 2005 at the Harris Park gauge site complied with Oregon Department of Environmental Quality (ODEQ) water quality standards for temperature, pH and dissolved oxygen standards. Dissolved oxygen data met the criteria of greater than 8 mg/l (ppm) over a 30-day mean minimum. Ranges enforced by ODEQ for pH reveal that Harris Park gauge data falls in mid-range of the 6.5 to 8.5 standard.

Plans for 2006

Since we’ve answered our initial questions with regards to bull trout distribution among stream segments, we will discontinue snorkel surveys during 2006. During 2006, thermographs will remain in the same deployment locations as 2005 to continue to collect year round temperature data. Stream temperature data may be used when analyzing bull trout movement data from PIT detections and in future habitat analysis.

We will continue investigating bull trout movement patterns, but a rotary screw trap will not be utilized at the Joe West Bridge trap site in 2006 due to low bull trout captures during both 2004 and 2005. We will continue operating PIT detection arrays at WW1, WW2, NBD, MCD and ORB, and we plan on adding two additional arrays during 2006. The installation of PIT detection arrays at Yellowhawk Creek and Burlingame Dam may allow a more thorough understanding of movements of individual fish between spawning and rearing habitats and movements of fish between local populations or Core Areas.

We will continue development of habitat suitability models. We will collect spawning habitat suitability data to validate the model developed in this report. Since snorkeling will be discontinued, no additional rearing habitat data will be collected. We will focus our efforts on completing the spawning habitat suitability model during 2006 and will further development of the rearing habitat suitability model in the future.

We will continue monitoring river stage to assure that spawning habitat suitability data are collected under the same conditions that are present when redds are constructed. In addition, monitoring river stage will allow us to determine the nature of instream working conditions for logistical planning.

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Appendix A

Table A1. Average minimum, mean and average maximum monthly temperature data from January to December 2005 for 16 thermographs located on the WWR.

Thermograph Location			Average monthly temperatures (°C)											
			January			February			March			April		
	Segment	rkm	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Site 15 (Harris Park)	NA	97.0	3.3	3.9	4.5	3.1	3.8	4.6	4.4	5.4	6.5	5.4	6.6	8.1
Site 14 (CTUIR hatchery)	NA	92.8	3.2	3.8	4.3	2.9	3.7	4.4	4.4	5.5	6.6	5.6	6.8	8.3
Site 13 (Red Steel Bridge)	NA	88.5	3.2	3.8	4.4	3.0	3.8	4.4	4.7	5.8	6.8	6.0	7.2	8.6
Site 12 (Upstream of forks)	NA	84.4	3.3	3.9	4.5	3.0	3.9	4.7	5.0	6.1	7.3	6.3	7.7	9.1
Site 11 (Downstream of forks)	2	83.1	3.2	3.8	4.4	2.9	3.8	4.9	5.1	6.2	7.6	6.5	7.8	9.4
Site 10 (Joe West Bridge)	2	82.0	3.2	3.8	4.5	2.9	3.9	5.0	5.2	6.3	7.8	6.6	8.0	9.5
Site 9 (Day Road)	2	80.5	3.3	3.9	4.5	3.0	4.0	5.2	5.3	6.5	8.0	6.8	8.1	9.7
Site 8 (Upstream of Grove St Bridge)	2	77.9	3.2	3.9	4.7	2.9	4.0	5.3	5.4	6.7	8.2	6.9	8.4	10.0
Site 7 (Cemetery Bridge)	2	76.3	3.4	4.0	4.7	2.9	4.0	5.4	5.4	6.8	8.5	7.0	8.5	10.1
Site 6 [a] (Nursery Bridge Dam)	1	74.2	3.1	3.7	4.5	2.7	3.9	5.5	5.4	6.8	8.8	6.9	8.5	10.4
Site 5 (Downstream NBD)	1	74.0	3.2	3.8	4.5	2.8	4.0	5.6	5.4	6.9	8.9	7.0	8.6	10.5
Site 4 (Levee Section)	1	72.2	3.2	3.9	4.6	2.8	4.1	5.9	5.5	7.2	9.5	7.2	8.9	11.0
Site 3 (Downstream of Tumalum)	1	70.0	3.1	3.8	4.5	2.7	4.1	6.1	5.5	7.4	9.9	7.3	9.0	11.4
Site 2 [b] (Between Tumalum & Pepper's)	1	68.4	3.1	3.8	4.6	2.8	4.1	6.1	6.0	7.6	9.5	7.3	9.1	11.4
Site 1 (Pepper's Bridge)	1	66.3	3.2	3.9	4.7	3.0	4.3	6.1	6.3	7.9	9.8	7.6	9.4	11.7
Site 16[c] (Oasis Road Bridge)	NA	10.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table A1 (continued)

Thermograph Location	Segment	rkm	May Min	May Avg	May Max	June Min	June Avg	June Max	July Min	July Avg	July Max	August Min	August Avg	August Max
			Average monthly temperatures (°C)											
Site 15 (Harris Park)	NA	97.0	7.4	8.8	10.7	8.0	10.0	12.5	8.9	11.6	14.9	8.5	10.8	13.7
Site 14 (CTUIR hatchery)	NA	92.8	7.7	9.2	11.0	8.4	10.4	12.8	9.5	12.3	15.2	9.2	11.5	13.9
Site 13 (Red Steel Bridge)	NA	88.5	8.2	9.7	11.4	9.2	11.2	13.1	10.9	13.3	15.3	10.6	12.6	14.1
Site 12 (Upstream of forks)	NA	84.4	8.8	10.3	11.9	10.0	11.9	13.8	12.0	14.3	16.4	11.7	13.6	15.4
Site 11 (Downstream of forks)	2	83.1	9.1	10.7	12.4	10.5	12.4	14.3	12.7	14.8	17.0	12.2	14.0	16.0
Site 10 (Joe West Bridge)	2	82.0	9.3	10.9	12.6	10.7	12.6	14.7	13.0	15.1	17.5	12.5	14.3	16.6
Site 9 (Day Road)	2	80.5	9.5	11.1	12.9	11.0	12.9	15.1	13.4	15.5	18.0	12.9	14.8	17.2
Site 8 (Upstream of Grove St Bridge)	2	77.9	9.7	11.4	13.2	11.3	13.3	15.6	13.7	16.0	18.7	13.2	15.2	17.8
Site 7 (Cemetery Bridge)	2	76.3	10.0	11.5	13.1	11.5	13.5	15.8	13.9	16.3	19.2	13.4	15.6	18.4
Site 6 [a] (Nursery Bridge Dam)	1	74.2	9.9	11.7	13.7	11.7*	13.9*	16.7*	14.2	16.8	20.3	13.7	16.2	19.6
Site 5 (Downstream NBD)	1	74.0	9.9	11.8	13.8	11.9*	14.1*	16.9*	14.7	17.1	20.1	13.9	16.4	19.7
Site 4 (Levee Section)	1	72.2	10.2	12.2	14.6	12.0*	14.9*	18.9*	14.6	18.2	23.0	13.9	17.3	22.0
Site 3 (Downstream of Tumalum)	1	70.0	10.4	12.5	15.2	12.4*	15.7*	19.9*	15.4	19.4	24.2	14.7	18.7	23.6
Site 2 [b] (Between Tumalum & Pepper's)	1	68.4	10.6	12.6	15.0	NA	NA	NA	NA	NA	NA	16.3	18.6	20.9
Site 1 (Pepper's Bridge)	1	66.3	10.9	12.9	15.3	13.7*	16.0*	18.9*	17.0	19.5	22.9	16.8	19.1	22.1
Site 16[c] (Oasis Road Bridge)	NA	10.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	22.0	23.8	25.5

Table A1 (continued).

Thermograph Location			Average monthly temperatures (°C)											
			September			October			November			December		
	Segment	rkm	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Site 15 (Harris Park)	NA	97.0	7.5	8.6	10.3	6.5	7.3	8.2	4.4	4.9	5.4	2.9*	3.5*	4.0*
Site 14 (CTUIR hatchery)	NA	92.8	7.4	8.8	10.2	6.9	7.7	8.5	4.6	5.1	5.6	2.7	3.1	3.7
Site 13 (Red Steel Bridge)	NA	88.5	8.6	9.8	10.7	7.5	8.2	8.8	4.5	5.1	5.5	2.7*	3.2*	3.7*
Site 12 (Upstream of forks)	NA	84.4	9.3	10.4	11.6	8.0	8.7	9.3	4.7	5.2	5.7	2.7	3.2	3.7
Site 11 (Downstream of forks)	2	83.1	9.8	10.9	12.3	8.3	9.0	9.8	4.9	5.4	5.9	2.6*	3.1*	3.7*
Site 10 (Joe West Bridge)	2	82.0	9.9	11.1	12.7	8.5	9.2	10.1	4.9	5.4	6.0	2.6*	3.1*	3.7*
Site 9 (Day Road)	2	80.5	10.3*	11.5*	13.0*	8.7	9.4	10.3	5.1	5.6	6.1	2.7	3.2	3.7
Site 8 (Upstream of Grove St Bridge)	2	77.9	10.5	11.8	13.5	8.8	9.6	10.6	5.0	5.6	6.1	2.6*	3.1*	3.7*
Site 7 (Cemetery Bridge)	2	76.3	10.6	12.0	13.9	8.9	9.8	10.9	5.1	5.7	6.3	2.7	3.1	3.6
Site 6 [a] (Nursery Bridge Dam)	1	74.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Site 5 (Downstream NBD)	1	74.0	10.8	12.4	14.9	9.0	10.0	11.6	4.8	5.5	6.2	2.3	2.8	3.4
Site 4 (Levee Section)	1	72.2	10.8*	13.1*	16.6*	8.9	10.4	12.5	4.6	5.4	6.4	2.3	2.8	3.4
Site 3 (Downstream of Tumalum)	1	70.0	11.1*	14.0*	17.9*	9.2	10.9	13.4	4.5	5.5	6.7	2.2	2.7	3.3
Site 2 [b] (Between Tumalum & Pepper's)	1	68.4	12.4*	14.3*	16.3*	10.1	11.3	12.8	5.5	6.2	7.0	2.4*	2.9*	3.4*
Site 1 (Pepper's Bridge)	1	66.3	13.0	14.7	16.6	10.4	11.5	12.8	6.0	6.7	7.3	2.5*	3.1*	3.6*
Site 16[c] (Oasis Road Bridge)	NA	10.1	16.6*	17.9*	18.7*	12.9	13.8	13.8	5.7	6.0	6.0	1.8	2.0	2.0

[a] Thermograph was lost. No data from September 20 to December 31, 2005.
[b] Thermograph found dry. No data from June 20 to July 26, 2005.
[c] Thermograph not launched until July 26, 2005.
* Thermograph data was outside the standard range of accuracy (+/- 0.4 °C).